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# LAKE KETCHUM ALGAE CONTROL PLAN TECHNICAL APPENDIX

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Public Works Department  
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With the assistance of



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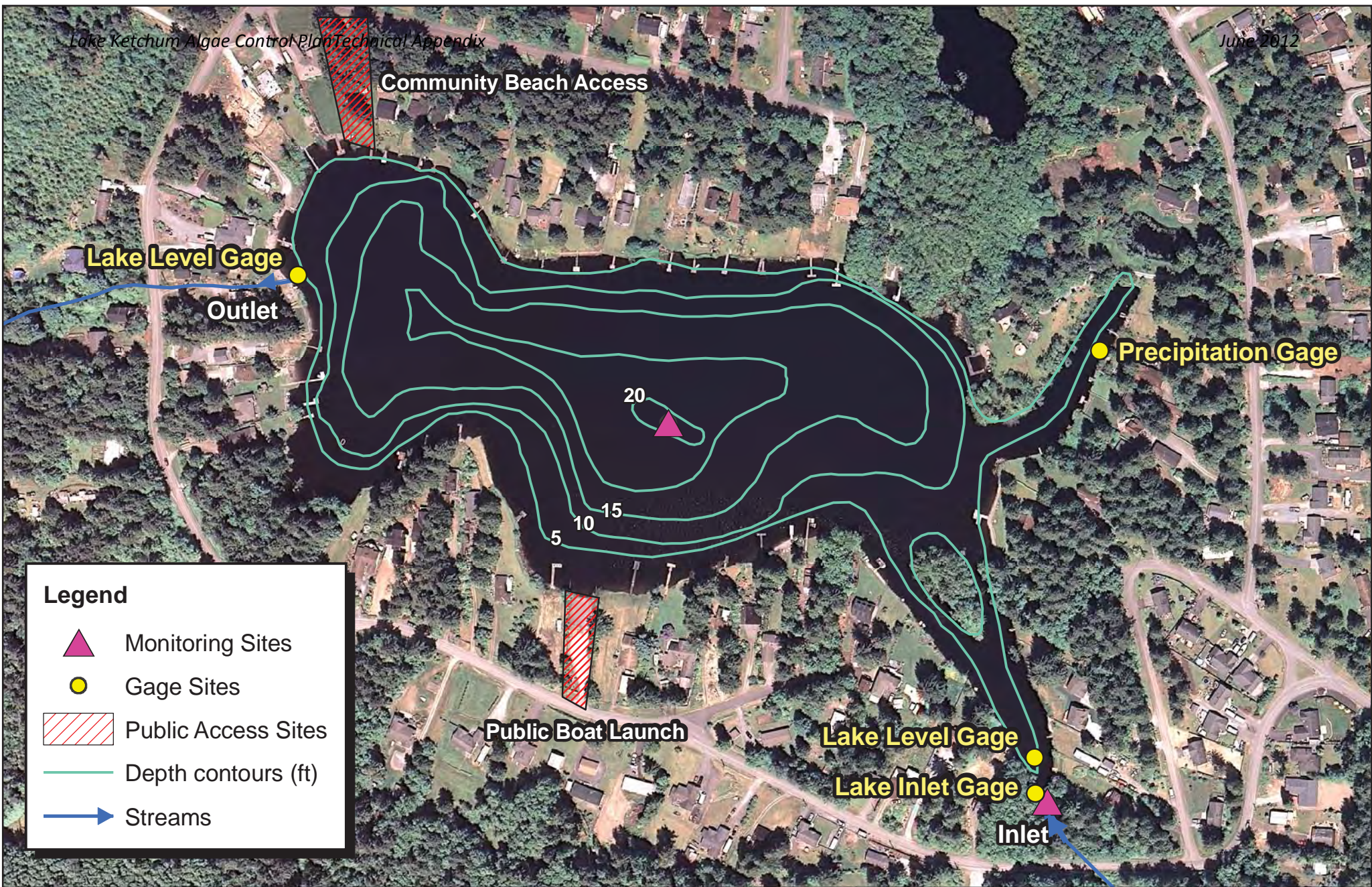
## A WATER QUALITY DATA

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Snohomish County Surface Water Management (SWM) conducted monthly or semi-monthly water quality monitoring of Lake Ketchum and its inlet stream from October 2010 through October 2011. The primary in-lake parameters examined were temperature, dissolved oxygen, water clarity, total phosphorus, soluble reactive phosphorus and chlorophyll *a*. Additional details on water monitoring methods and procedures for chemical analysis can be found in the Snohomish County Lake Management Program Quality Assurance Management Plan and in Appendix D of that document (Snohomish County, 2011a and 2011b). The following tables summarize the data collected during the study period as well as provide documentation of the sample chain of custodies and laboratory quality assurance results. Included in this section are the following:

- *Map of Monitoring Locations*
- *Water Clarity Data*
- *Lake Profile Data (temperature, dissolved oxygen, conductivity, and pH)*
- *In-Lake Chemical Data*
- *Inlet Chemical Data*
- *Lab Reports and Chain of Custody Forms*





0 125 250 500 Feet

# Lake Ketchum Monitoring and Gaging Locations



Snohomish County

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(425) 388-3464

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**Lake Ketchum Secchi Disk Readings - September 2010 - October 2011**

Lake	Date	Time	Secchi Depth (meters)	Source
Ketchum	9/12/2010	1:30:00	2.1	Volunteer
Ketchum	9/30/2010	1:30:00	1.9	Staff
Ketchum	10/20/2010	10:30:00	0.8	Staff
Ketchum	11/15/2010	11:30:00	1.2	Staff
Ketchum	12/13/2010	11:00:00	1.2	Staff
Ketchum	1/13/2011	10:45:00	1.2	Staff
Ketchum	2/17/2011	12:40:00	1.4	Staff
Ketchum	3/17/2011	11:15:00	1.5	Staff
Ketchum	4/11/2011	11:30:00	1	Staff
Ketchum	4/25/2011	11:30:00	1.1	Staff
Ketchum	5/12/2011	2:00:00	1.5	Staff
Ketchum	5/24/2011	10:45:00	0.45	Staff
Ketchum	6/7/2011	1:30:00	0.5	Staff
Ketchum	6/22/2011	12:30:00	0.45	Staff
Ketchum	7/13/2011	10:53:00	1.65	Staff
Ketchum	8/10/2011	11:00:00	1.1	Staff
Ketchum	8/24/2011	10:45:00	1.1	Staff
Ketchum	9/13/2011	2:15:00	1.25	Staff
Ketchum	9/28/2011	11:10:00	0.9	Staff
Ketchum	10/12/2011	10:45:00	0.8	Staff
Ketchum	10/21/2011	10:30:00	0.9	Staff

## Lake Ketchum Profiles September 2010 - October 2011

Lake	Date	Hour	Depth	Temp °C	DO (mg/l)	Conductivity (umhos/cm)	pH
Ketchum	9/30/2010	1:30 AM	0	17.11	8.68	137.6	7.42
Ketchum	9/30/2010	1:30 AM	1	16.87	8.49	137.4	7.33
Ketchum	9/30/2010	1:30 AM	2	16.58	8.2	137.2	7.22
Ketchum	9/30/2010	1:30 AM	3	16.26	5.75	140.3	6.87
Ketchum	9/30/2010	1:30 AM	4	14.06	0.36	166.2	6.28
Ketchum	9/30/2010	1:30 AM	5	11.62	0.37	222.9	6.15
Ketchum	9/30/2010	1:30 AM	6	10.62	0.3	243.6	6.09
Ketchum	10/20/2010	10:30 AM	0	12.74	5.89	129.2	7.05
Ketchum	10/20/2010	10:30 AM	1	12.61	5.53	129.1	6.92
Ketchum	10/20/2010	10:30 AM	2	12.6	5.33	129.1	6.85
Ketchum	10/20/2010	10:30 AM	3	12.55	5.18	129.7	6.79
Ketchum	10/20/2010	10:30 AM	4	12.52	4.97	130.1	6.74
Ketchum	10/20/2010	10:30 AM	5	12.4	3.63	134.9	6.61
Ketchum	10/20/2010	10:30 AM	6	11.33	1.35	232.6	6.06
Ketchum	11/15/2010	11:30 AM	0	9.22	7.08	128.4	6.93
Ketchum	11/15/2010	11:30 AM	1	9.19	6.58	128.7	6.82
Ketchum	11/15/2010	11:30 AM	2	9.13	6.58	128.3	6.76
Ketchum	11/15/2010	11:30 AM	3	9.13	6.55	128.8	6.74
Ketchum	11/15/2010	11:30 AM	4	9.14	6.49	128.9	6.72
Ketchum	11/15/2010	11:30 AM	5	9.13	6.25	129.1	6.7
Ketchum	11/15/2010	11:30 AM	6	9.13	6.23	128.9	6.68
Ketchum	12/13/2010	11:00 AM	0	5.87	9.25	125	7.19
Ketchum	12/13/2010	11:00 AM	1	5.76	9.11	125.3	7.03
Ketchum	12/13/2010	11:00 AM	2	5.4	8.84	125.5	6.93
Ketchum	12/13/2010	11:00 AM	3	5.39	8.79	125.6	6.92
Ketchum	12/13/2010	11:00 AM	4	5.39	8.52	125.4	6.9
Ketchum	12/13/2010	11:00 AM	5	5.32	8.34	125.6	6.85
Ketchum	12/13/2010	11:00 AM	6	5.29	8.12	125.7	6.81
Ketchum	1/13/2011	10:45 AM	0	3.44	9.4	117.7	6.67
Ketchum	1/13/2011	10:45 AM	1	3.4	9.39	118	6.67
Ketchum	1/13/2011	10:45 AM	2	3.39	9.36	118.1	6.65
Ketchum	1/13/2011	10:45 AM	3	3.37	9.36	118	6.65
Ketchum	1/13/2011	10:45 AM	4	3.38	9.31	118	6.65
Ketchum	1/13/2011	10:45 AM	5	3.37	9.2	117.9	6.63
Ketchum	2/17/2011	12:40 PM	0	5.57	10.12	126.9	7.03
Ketchum	2/17/2011	12:40 PM	1	5.57	9.8	127.1	6.98
Ketchum	2/17/2011	12:40 PM	2	5.55	9.74	127.1	6.97
Ketchum	2/17/2011	12:40 PM	3	5.53	9.62	127.1	6.96
Ketchum	2/17/2011	12:40 PM	4	5.53	9.64	127.1	6.96
Ketchum	2/17/2011	12:40 PM	5	5.51	9.52	127.3	6.97
Ketchum	3/17/2011	11:15 AM	0	6.99	10.84	129.4	6.96
Ketchum	3/17/2011	11:15 AM	1	6.82	10.82	129.1	6.92
Ketchum	3/17/2011	11:15 AM	2	6.63	10.62	129.3	6.89



Lake	Date	Hour	Depth	Temp °C	DO (mg/l)	Conductivity (umhos/cm)	pH
Ketchum	3/17/2011	11:15 AM	3	6.62	10.55	129.2	6.86
Ketchum	3/17/2011	11:15 AM	4	6.61	10.34	129	6.83
Ketchum	3/17/2011	11:15 AM	5	6.59	10.22	129.9	6.8
Ketchum	4/11/2011	11:30 AM	0	9.3	12.61	119.1	7.62
Ketchum	4/11/2011	11:30 AM	1	9.25	12.67	119.2	7.47
Ketchum	4/11/2011	11:30 AM	2	9.19	12.68	119.1	7.4
Ketchum	4/11/2011	11:30 AM	3	8.93	11.49	120.5	7
Ketchum	4/11/2011	11:30 AM	4	8.33	10.07	121.3	6.82
Ketchum	4/11/2011	11:30 AM	5	7.78	6.12	127.6	6.64
Ketchum	4/11/2011	11:30 AM	6	7.59	4.07	132.4	6.49
Ketchum	4/25/2011	11:30 AM	0	12.58	12.83	119.8	8.97
Ketchum	4/25/2011	11:30 AM	1	12.38	13.08	120.2	8.94
Ketchum	4/25/2011	11:30 AM	2	10.78	13.1	120.4	7.64
Ketchum	4/25/2011	11:30 AM	3	9.03	10.43	122.2	6.94
Ketchum	4/25/2011	11:30 AM	4	8.57	7.06	126.3	6.7
Ketchum	4/25/2011	11:30 AM	5	8.29	4.18	132.3	6.52
Ketchum	4/25/2011	11:30 AM	6	8.18	3.33	134.7	6.48
Ketchum	5/12/2011	2:00 AM	0	14.75	12.09	121.5	8.5
Ketchum	5/12/2011	2:00 AM	1	13.79	12.2	120.2	8.14
Ketchum	5/12/2011	2:00 AM	2	12.36	9.79	123.8	6.93
Ketchum	5/12/2011	2:00 AM	3	10.4	6.64	129.1	6.52
Ketchum	5/12/2011	2:00 AM	4	8.77	0.49	137.8	6.34
Ketchum	5/12/2011	2:00 AM	5	8.35	0.46	155.6	6.34
Ketchum	5/24/2011	10:45 AM	0	16.74	16.76	144.1	10.17
Ketchum	5/24/2011	10:45 AM	1	16.4	15.85	128.9	9.79
Ketchum	5/24/2011	10:45 AM	2	12.82	6.87	128	6.55
Ketchum	5/24/2011	10:45 AM	3	10.21	1.52	137.1	6.32
Ketchum	5/24/2011	10:45 AM	4	8.96	0.87	150.1	6.29
Ketchum	5/24/2011	10:45 AM	5	8.52	0.67	161.2	6.34
Ketchum	6/7/2011	1:30 AM	0	20.14	13.3	148	10.2
Ketchum	6/7/2011	1:30 AM	1	18.52	10.68	126.2	9.11
Ketchum	6/7/2011	1:30 AM	2	13.98	4.59	130.7	7.3
Ketchum	6/7/2011	1:30 AM	3	10.91	0.8	142.7	6.54
Ketchum	6/7/2011	1:30 AM	4	9.17	0.32	160.3	6.45
Ketchum	6/7/2011	1:30 AM	5	8.64	0.2	173.4	6.43
Ketchum	6/7/2011	1:30 AM	6	8.51	0.18	176.4	6.4
Ketchum	6/22/2011	12:30 PM	0	20.34	10.78	127.3	9.45
Ketchum	6/22/2011	12:30 PM	1	17.78	7.4	124.2	8.38
Ketchum	6/22/2011	12:30 PM	2	14.49	2.00	135.1	6.73
Ketchum	6/22/2011	12:30 PM	3	11.01	0.84	147	6.44
Ketchum	6/22/2011	12:30 PM	4	9.46	0.42	164.9	6.45
Ketchum	6/22/2011	12:30 PM	5	8.8	0.28	179.7	6.39
Ketchum	6/22/2011	12:30 PM	6	8.68	0.18	185.2	6.34
Ketchum	7/13/2011	10:53 AM	0	20.59	6.77	129.1	7.84

Lake	Date	Hour	Depth	Temp °C	DO (mg/l)	Conductivity (umhos/cm)	pH
Ketchum	7/13/2011	10:53 AM	1	20.49	7.02	129.2	8.06
Ketchum	7/13/2011	10:53 AM	2	17.18	0.59	139.7	6.76
Ketchum	7/13/2011	10:53 AM	3	12.13	0.09	152.8	6.38
Ketchum	7/13/2011	10:53 AM	4	9.83	0.12	168.2	6.43
Ketchum	7/13/2011	10:53 AM	5	8.99	0.14	194.9	6.32
Ketchum	7/27/2011	11:00 AM	0.5	19.76	12.59	127	9.08
Ketchum	7/27/2011	11:00 AM	1	19.62	12.0	126.3	8.91
Ketchum	7/27/2011	11:00 AM	2	17.78	1.58	129.5	6.59
Ketchum	7/27/2011	11:00 AM	3	12.62	1.03	155.5	6.41
Ketchum	7/27/2011	11:00 AM	4	10.13	0.88	172.2	6.44
Ketchum	7/27/2011	11:00 AM	5	9.1	0.78	207.3	6.33
Ketchum	8/10/2011	11:00 AM	0	20.09	9.34	127.5	9.24
Ketchum	8/10/2011	11:00 AM	1	20.05	9.21	127.1	9.19
Ketchum	8/10/2011	11:00 AM	2	17.52	1.72	128.7	6.76
Ketchum	8/10/2011	11:00 AM	3	13.42	0.67	155.4	6.42
Ketchum	8/10/2011	11:00 AM	4	10.37	0.46	177.1	6.44
Ketchum	8/10/2011	11:00 AM	5	9.07	0.36	208.9	6.32
Ketchum	8/10/2011	11:00 AM	6	8.96	0.26	230.4	6.26
Ketchum	8/24/2011	10:45 AM	0	21.06	8.96	130.2	9.16
Ketchum	8/24/2011	10:45 AM	1	20.83	9.11	129.4	9.21
Ketchum	8/24/2011	10:45 AM	2	19.63	2.62	130.9	7.28
Ketchum	8/24/2011	10:45 AM	3	14.36	0.56	157.2	6.46
Ketchum	8/24/2011	10:45 AM	4	10.61	0.42	187.2	6.47
Ketchum	8/24/2011	10:45 AM	5	9.58	0.34	214.4	6.39
Ketchum	9/13/2011	2:15:00PM	0	20.83	8.66	128	7.06
Ketchum	9/13/2011	2:15:00PM	1	20.03	7.91	128	7.08
Ketchum	9/13/2011	2:15:00PM	2	19.8	5.06	127	7.17
Ketchum	9/13/2011	2:15:00PM	3	15.52	0.53	147	6.77
Ketchum	9/13/2011	2:15:00PM	4	11.48	0.56	180	6.66
Ketchum	9/13/2011	2:15:00PM	5	9.84	0.62	215	6.57
Ketchum	9/28/2011	11:10:00AM	0	16.48	7.77	130.9	7.26
Ketchum	9/28/2011	11:10:00AM	1	16.37	7.71	130.5	7.25
Ketchum	9/28/2011	11:10:00AM	2	16.34	7.86	130.5	7.29
Ketchum	9/28/2011	11:10:00AM	3	16.32	7.66	130.1	7.25
Ketchum	9/28/2011	11:10:00AM	4	11.79	0.2	192.7	6.39
Ketchum	9/28/2011	11:10:00AM	5	10	0.12	230.2	6.28
Ketchum	10/12/2011	10:45 AM	0	13.86	7.63	131.9	7.09
Ketchum	10/12/2011	10:45 AM	1	13.78	6.81	131.8	6.91
Ketchum	10/12/2011	10:45 AM	2	13.74	6.45	131.9	6.77
Ketchum	10/12/2011	10:45 AM	3	13.73	6.02	132.3	6.67
Ketchum	10/12/2011	10:45 AM	4	13.52	0.76	141.7	6.27
Ketchum	10/12/2011	10:45 AM	5	10.77	0.42	231	6.18
Ketchum	10/12/2011	10:45 AM	6	9.9	0.28	263.5	6.03
Ketchum	10/21/2011	10:30 AM	0	12.58	6.45	123.8	7.04

Lake	Date	Hour	Depth	Temp °C	DO (mg/l)	Conductivity (umhos/cm)	pH
Ketchum	10/21/2011	10:30 AM	1	12.56	6.28	123.3	6.98
Ketchum	10/21/2011	10:30 AM	2	12.56	6.20	123.4	6.78
Ketchum	10/21/2011	10:30 AM	3	12.55	5.97	123.4	6.7
Ketchum	10/21/2011	10:30 AM	4	12.52	5.95	124.7	6.65
Ketchum	10/21/2011	10:30 AM	5	11.32	0.20	205.8	6.03
Ketchum	10/21/2011	10:30 AM	6	10.36	0.19	238.8	6.07

**Lake Ketchum Chemical Data June 2010 - October 2011**

Lake	Date	Hour	Parameter	Units	Value	Depth	Source	Code
Ketchum	9/12/2010	1:30 AM	Chlorophyll <i>a</i>	ug/l	7.2	1	Staff	
Ketchum	10/20/2010	11:00 AM	Chlorophyll <i>a</i>	ug/l	42	1	Staff	
Ketchum	12/13/2010	11:15 AM	Chlorophyll <i>a</i>	ug/l	23	1	Staff	
Ketchum	1/13/2011	11:00 AM	Chlorophyll <i>a</i>	ug/l	10.5	1	Staff	D
Ketchum	2/17/2011	1:00 AM	Chlorophyll <i>a</i>	ug/l	8	1	Staff	
Ketchum	3/17/2011	11:30 AM	Chlorophyll <i>a</i>	ug/l	20	1	Staff	
Ketchum	4/11/2011	11:45 AM	Chlorophyll <i>a</i>	ug/l	62	1	Staff	D
Ketchum	4/23/2011	12:00 PM	Chlorophyll <i>a</i>	ug/l	52	1	Staff	
Ketchum	5/24/2011	11:00 AM	Chlorophyll <i>a</i>	ug/l	64	1	Staff	
Ketchum	6/7/2011	1:30 AM	Chlorophyll <i>a</i>	ug/l	174	1	Staff	
Ketchum	6/22/2011	12:45 PM	Chlorophyll <i>a</i>	ug/l	47	1	Staff	
Ketchum	7/13/2011	10:55 AM	Chlorophyll <i>a</i>	ug/l	17.5	1	Staff	D
Ketchum	7/27/2011	10:45 AM	Chlorophyll <i>a</i>	ug/l	76	1	Staff	
Ketchum	8/10/2011	11:30 AM	Chlorophyll <i>a</i>	ug/l	47	1	Staff	D
Ketchum	8/24/2011	10:55 AM	Chlorophyll <i>a</i>	ug/l	43	1	Staff	D
Ketchum	9/13/2011	2:15 AM	Chlorophyll <i>a</i>	ug/l	23	1	Staff	
Ketchum	9/28/2011	11:10 AM	Chlorophyll <i>a</i>	ug/l	54	1	Staff	
Ketchum	10/12/2011	10:45 AM	Chlorophyll <i>a</i>	ug/l	184	1	Staff	
Ketchum	10/21/2011	10:30 AM	Chlorophyll <i>a</i>	ug/l	163	1	Staff	
Ketchum	10/20/2010	11:00 AM	Phosphorus - Soluble Reactive	ug/l	276	1	Staff	
Ketchum	10/20/2010	11:00 AM	Phosphorus - Soluble Reactive	ug/l	281	2	Staff	
Ketchum	10/20/2010	11:00 AM	Phosphorus - Soluble Reactive	ug/l	289	4	Staff	
Ketchum	10/20/2010	11:00 AM	Phosphorus - Soluble Reactive	ug/l	368	5	Staff	
Ketchum	11/15/2010	11:30 AM	Phosphorus - Soluble Reactive	ug/l	286	1	Staff	
Ketchum	11/15/2010	11:30 AM	Phosphorus - Soluble Reactive	ug/l	310	2	Staff	
Ketchum	11/15/2010	11:30 AM	Phosphorus - Soluble Reactive	ug/l	315	4	Staff	
Ketchum	11/15/2010	11:30 AM	Phosphorus - Soluble Reactive	ug/l	325	5	Staff	
Ketchum	12/13/2010	11:15 AM	Phosphorus - Soluble Reactive	ug/l	221	1	Staff	
Ketchum	12/13/2010	11:15 AM	Phosphorus - Soluble Reactive	ug/l	238	2	Staff	
Ketchum	12/13/2010	11:15 AM	Phosphorus - Soluble Reactive	ug/l	236	4	Staff	
Ketchum	12/13/2010	11:15 AM	Phosphorus - Soluble Reactive	ug/l	250	5	Staff	
Ketchum	1/13/2011	11:00 AM	Phosphorus - Soluble Reactive	ug/l	209	1	Staff	D
Ketchum	1/13/2011	11:00 AM	Phosphorus - Soluble Reactive	ug/l	215	2	Staff	
Ketchum	1/13/2011	11:00 AM	Phosphorus - Soluble Reactive	ug/l	221	4	Staff	
Ketchum	1/13/2011	11:00 AM	Phosphorus - Soluble Reactive	ug/l	218	5	Staff	
Ketchum	2/17/2011	1:00 AM	Phosphorus - Soluble Reactive	ug/l	141	1	Staff	
Ketchum	2/17/2011	1:00 AM	Phosphorus - Soluble Reactive	ug/l	146	2	Staff	
Ketchum	2/17/2011	1:00 AM	Phosphorus - Soluble Reactive	ug/l	190	4	Staff	
Ketchum	2/17/2011	1:00 AM	Phosphorus - Soluble Reactive	ug/l	153	5	Staff	
Ketchum	3/17/2011	11:30 AM	Phosphorus - Soluble Reactive	ug/l	112	1	Staff	
Ketchum	3/17/2011	11:30 AM	Phosphorus - Soluble Reactive	ug/l	117	2	Staff	
Ketchum	3/17/2011	11:30 AM	Phosphorus - Soluble Reactive	ug/l	120	4	Staff	
Ketchum	3/17/2011	11:30 AM	Phosphorus - Soluble Reactive	ug/l	119	5	Staff	
Ketchum	4/11/2011	11:45 AM	Phosphorus - Soluble Reactive	ug/l	75	1	Staff	D

**Lake Ketchum Chemical Data June 2010 - October 2011**

Lake	Date	Hour	Parameter	Units	Value	Depth	Source	Code
Ketchum	4/11/2011	11:45 AM	Phosphorus - Soluble Reactive	ug/l	78	2	Staff	
Ketchum	4/11/2011	11:45 AM	Phosphorus - Soluble Reactive	ug/l	126	4	Staff	
Ketchum	4/11/2011	11:45 AM	Phosphorus - Soluble Reactive	ug/l	251	5	Staff	
Ketchum	4/23/2011	12:00 PM	Phosphorus - Soluble Reactive	ug/l	20	1	Staff	
Ketchum	4/23/2011	12:00 PM	Phosphorus - Soluble Reactive	ug/l	22.5	2	Staff	D
Ketchum	4/23/2011	12:00 PM	Phosphorus - Soluble Reactive	ug/l	36	4	Staff	
Ketchum	4/23/2011	12:00 PM	Phosphorus - Soluble Reactive	ug/l	427	5	Staff	
Ketchum	5/12/2011	2:00 AM	Phosphorus - Soluble Reactive	ug/l	33	1	Staff	
Ketchum	5/12/2011	2:00 AM	Phosphorus - Soluble Reactive	ug/l	47	2	Staff	
Ketchum	5/12/2011	2:00 AM	Phosphorus - Soluble Reactive	ug/l	261.5	4	Staff	D
Ketchum	5/12/2011	2:00 AM	Phosphorus - Soluble Reactive	ug/l	915	5	Staff	
Ketchum	5/24/2011	11:00 AM	Phosphorus - Soluble Reactive	ug/l	22	1	Staff	
Ketchum	5/24/2011	11:00 AM	Phosphorus - Soluble Reactive	ug/l	110	2	Staff	
Ketchum	5/24/2011	11:00 AM	Phosphorus - Soluble Reactive	ug/l	566	4	Staff	
Ketchum	5/24/2011	11:00 AM	Phosphorus - Soluble Reactive	ug/l	1250	5	Staff	D
Ketchum	6/7/2011	1:30 AM	Phosphorus - Soluble Reactive	ug/l	8	1	Staff	
Ketchum	6/7/2011	1:30 AM	Phosphorus - Soluble Reactive	ug/l	25	2	Staff	D
Ketchum	6/7/2011	1:30 AM	Phosphorus - Soluble Reactive	ug/l	910	4	Staff	
Ketchum	6/7/2011	1:30 AM	Phosphorus - Soluble Reactive	ug/l	2010	5	Staff	
Ketchum	6/22/2011	12:45 PM	Phosphorus - Soluble Reactive	ug/l	4	1	Staff	
Ketchum	6/22/2011	12:45 PM	Phosphorus - Soluble Reactive	ug/l	77	2	Staff	D
Ketchum	6/22/2011	12:45 PM	Phosphorus - Soluble Reactive	ug/l	766	4	Staff	
Ketchum	6/22/2011	12:45 PM	Phosphorus - Soluble Reactive	ug/l	2180	5	Staff	
Ketchum	7/13/2011	10:55 AM	Phosphorus - Soluble Reactive	ug/l	2	1	Staff	
Ketchum	7/13/2011	10:55 AM	Phosphorus - Soluble Reactive	ug/l	2	2	Staff	
Ketchum	7/13/2011	10:55 AM	Phosphorus - Soluble Reactive	ug/l	973	4	Staff	
Ketchum	7/13/2011	10:55 AM	Phosphorus - Soluble Reactive	ug/l	1545	5	Staff	D
Ketchum	7/27/2011	10:45 AM	Phosphorus - Soluble Reactive	ug/l	5	1	Staff	
Ketchum	7/27/2011	10:45 AM	Phosphorus - Soluble Reactive	ug/l	8	2	Staff	
Ketchum	7/27/2011	10:45 AM	Phosphorus - Soluble Reactive	ug/l	1115	4	Staff	D
Ketchum	7/27/2011	10:45 AM	Phosphorus - Soluble Reactive	ug/l	3120	5	Staff	
Ketchum	8/10/2011	11:30 AM	Phosphorus - Soluble Reactive	ug/l	5	1	Staff	
Ketchum	8/10/2011	11:30 AM	Phosphorus - Soluble Reactive	ug/l	11	2	Staff	
Ketchum	8/10/2011	11:30 AM	Phosphorus - Soluble Reactive	ug/l	1445	4	Staff	D
Ketchum	8/10/2011	11:30 AM	Phosphorus - Soluble Reactive	ug/l	2470	5	Staff	
Ketchum	8/24/2011	10:55 AM	Phosphorus - Soluble Reactive	ug/l	4	1	Staff	
Ketchum	8/24/2011	10:55 AM	Phosphorus - Soluble Reactive	ug/l	8	2	Staff	
Ketchum	8/24/2011	10:55 AM	Phosphorus - Soluble Reactive	ug/l	1830	4	Staff	
Ketchum	8/24/2011	10:55 AM	Phosphorus - Soluble Reactive	ug/l	2455	5	Staff	D
Ketchum	9/13/2011	2:15 AM	Phosphorus - Soluble Reactive	ug/l	10	1	Staff	
Ketchum	9/13/2011	2:15 AM	Phosphorus - Soluble Reactive	ug/l	51	2	Staff	
Ketchum	9/13/2011	2:15 AM	Phosphorus - Soluble Reactive	ug/l	2550	4	Staff	
Ketchum	9/13/2011	2:15 AM	Phosphorus - Soluble Reactive	ug/l	3230	5	Staff	
Ketchum	9/28/2011	11:10 AM	Phosphorus - Soluble Reactive	ug/l	114	1	Staff	



**Lake Ketchum Chemical Data June 2010 - October 2011**

Lake	Date	Hour	Parameter	Units	Value	Depth	Source	Code
Ketchum	9/28/2011	11:10 AM	Phosphorus - Soluble Reactive	ug/l	118	2	Staff	D
Ketchum	9/28/2011	11:10 AM	Phosphorus - Soluble Reactive	ug/l	1560	4	Staff	
Ketchum	9/28/2011	11:10 AM	Phosphorus - Soluble Reactive	ug/l	3120	5	Staff	
Ketchum	10/12/2011	10:45 AM	Phosphorus - Soluble Reactive	ug/l	281	1	Staff	
Ketchum	10/12/2011	10:45 AM	Phosphorus - Soluble Reactive	ug/l	267	2	Staff	
Ketchum	10/12/2011	10:45 AM	Phosphorus - Soluble Reactive	ug/l	375	4	Staff	
Ketchum	10/12/2011	10:45 AM	Phosphorus - Soluble Reactive	ug/l	2400	5	Staff	
Ketchum	10/21/2011	10:30 AM	Phosphorus - Soluble Reactive	ug/l	335	1	Staff	
Ketchum	10/21/2011	10:30 AM	Phosphorus - Soluble Reactive	ug/l	337	2	Staff	
Ketchum	10/21/2011	10:30 AM	Phosphorus - Soluble Reactive	ug/l	344	4	Staff	
Ketchum	10/21/2011	10:30 AM	Phosphorus - Soluble Reactive	ug/l	1290	5	Staff	
Ketchum	6/13/2010	2:00 AM	Phosphorus - total	ug/l	183	1	Volunteer	
Ketchum	6/13/2010	2:00 AM	Phosphorus - total	ug/l	1260	5	Volunteer	
Ketchum	7/11/2010	12:30 PM	Phosphorus - total	ug/l	242	1	Volunteer	
Ketchum	7/11/2010	12:30 PM	Phosphorus - total	ug/l	2030	5	Volunteer	
Ketchum	8/13/2010	10:00 AM	Phosphorus - total	ug/l	200	1	Volunteer	
Ketchum	8/13/2010	10:00 AM	Phosphorus - total	ug/l	441	5	Volunteer	
Ketchum	9/12/2010	1:30 AM	Phosphorus - total	ug/l	157	1	Volunteer	
Ketchum	9/12/2010	1:30 AM	Phosphorus - total	ug/l	2180	5	Volunteer	
Ketchum	10/20/2010	11:00 AM	Phosphorus - total	ug/l	459	1	Staff	
Ketchum	10/20/2010	11:00 AM	Phosphorus - total	ug/l	412	2	Staff	
Ketchum	10/20/2010	11:00 AM	Phosphorus - total	ug/l	433	4	Staff	
Ketchum	10/20/2010	11:00 AM	Phosphorus - total	ug/l	522	5	Staff	
Ketchum	11/15/2010	11:30 AM	Phosphorus - total	ug/l	444	1	Staff	
Ketchum	11/15/2010	11:30 AM	Phosphorus - total	ug/l	441	2	Staff	
Ketchum	11/15/2010	11:30 AM	Phosphorus - total	ug/l	458	4	Staff	
Ketchum	11/15/2010	11:30 AM	Phosphorus - total	ug/l	456	5	Staff	
Ketchum	12/13/2010	11:15 AM	Phosphorus - total	ug/l	398	1	Staff	D
Ketchum	12/13/2010	11:15 AM	Phosphorus - total	ug/l	399	2	Staff	
Ketchum	12/13/2010	11:15 AM	Phosphorus - total	ug/l	400	4	Staff	
Ketchum	12/13/2010	11:15 AM	Phosphorus - total	ug/l	405	5	Staff	
Ketchum	1/13/2011	11:00 AM	Phosphorus - total	ug/l	351	1	Staff	
Ketchum	1/13/2011	11:00 AM	Phosphorus - total	ug/l	343	2	Staff	
Ketchum	1/13/2011	11:00 AM	Phosphorus - total	ug/l	346	4	Staff	
Ketchum	1/13/2011	11:00 AM	Phosphorus - total	ug/l	347	5	Staff	
Ketchum	2/17/2011	1:00 AM	Phosphorus - total	ug/l	266	1	Staff	
Ketchum	2/17/2011	1:00 AM	Phosphorus - total	ug/l	277	2	Staff	
Ketchum	2/17/2011	1:00 AM	Phosphorus - total	ug/l	251	4	Staff	
Ketchum	2/17/2011	1:00 AM	Phosphorus - total	ug/l	259	5	Staff	
Ketchum	3/17/2011	11:30 AM	Phosphorus - total	ug/l	188	1	Staff	
Ketchum	3/17/2011	11:30 AM	Phosphorus - total	ug/l	174	2	Staff	
Ketchum	3/17/2011	11:30 AM	Phosphorus - total	ug/l	176	4	Staff	
Ketchum	3/17/2011	11:30 AM	Phosphorus - total	ug/l	188	5	Staff	
Ketchum	4/11/2011	11:45 AM	Phosphorus - total	ug/l	167	2	Staff	D

**Lake Ketchum Chemical Data June 2010 - October 2011**

Lake	Date	Hour	Parameter	Units	Value	Depth	Source	Code
Ketchum	4/11/2011	11:45 AM	Phosphorus - total	ug/l	205	4	Staff	
Ketchum	4/11/2011	11:45 AM	Phosphorus - total	ug/l	355	5	Staff	
Ketchum	4/23/2011	12:00 PM	Phosphorus - total	ug/l	127	1	Staff	
Ketchum	4/23/2011	12:00 PM	Phosphorus - total	ug/l	125	2	Staff	
Ketchum	4/23/2011	12:00 PM	Phosphorus - total	ug/l	134	4	Staff	D
Ketchum	4/23/2011	12:00 PM	Phosphorus - total	ug/l	631	5	Staff	
Ketchum	5/12/2011	2:00 AM	Phosphorus - total	ug/l	127	1	Staff	
Ketchum	5/12/2011	2:00 AM	Phosphorus - total	ug/l	130	2	Staff	
Ketchum	5/12/2011	2:00 AM	Phosphorus - total	ug/l	344.5	4	Staff	
Ketchum	5/12/2011	2:00 AM	Phosphorus - total	ug/l	1550	5	Staff	D
Ketchum	5/24/2011	11:00 AM	Phosphorus - total	ug/l	135	1	Staff	
Ketchum	5/24/2011	11:00 AM	Phosphorus - total	ug/l	167	2	Staff	D
Ketchum	5/24/2011	11:00 AM	Phosphorus - total	ug/l	775	4	Staff	
Ketchum	5/24/2011	11:00 AM	Phosphorus - total	ug/l	1695	5	Staff	
Ketchum	6/7/2011	1:30 AM	Phosphorus - total	ug/l	172	1	Staff	
Ketchum	6/7/2011	1:30 AM	Phosphorus - total	ug/l	121	2	Staff	D
Ketchum	6/7/2011	1:30 AM	Phosphorus - total	ug/l	1160	4	Staff	
Ketchum	6/7/2011	1:30 AM	Phosphorus - total	ug/l	2450	5	Staff	
Ketchum	6/22/2011	12:45 PM	Phosphorus - total	ug/l	119	1	Staff	
Ketchum	6/22/2011	12:45 PM	Phosphorus - total	ug/l	157	2	Staff	
Ketchum	6/22/2011	12:45 PM	Phosphorus - total	ug/l	972	4	Staff	
Ketchum	6/22/2011	12:45 PM	Phosphorus - total	ug/l	2820	5	Staff	D
Ketchum	7/13/2011	10:55 AM	Phosphorus - total	ug/l	78	1	Staff	
Ketchum	7/13/2011	10:55 AM	Phosphorus - total	ug/l	86	2	Staff	
Ketchum	7/13/2011	10:55 AM	Phosphorus - total	ug/l	1090	4	Staff	D
Ketchum	7/13/2011	10:55 AM	Phosphorus - total	ug/l	1905	5	Staff	
Ketchum	7/27/2011	10:45 AM	Phosphorus - total	ug/l	89	1	Staff	
Ketchum	7/27/2011	10:45 AM	Phosphorus - total	ug/l	127	2	Staff	
Ketchum	7/27/2011	10:45 AM	Phosphorus - total	ug/l	1320	4	Staff	D
Ketchum	7/27/2011	10:45 AM	Phosphorus - total	ug/l	3610	5	Staff	
Ketchum	8/10/2011	11:30 AM	Phosphorus - total	ug/l	72	1	Staff	
Ketchum	8/10/2011	11:30 AM	Phosphorus - total	ug/l	128	2	Staff	
Ketchum	8/10/2011	11:30 AM	Phosphorus - total	ug/l	1825	4	Staff	
Ketchum	8/10/2011	11:30 AM	Phosphorus - total	ug/l	3160	5	Staff	D
Ketchum	8/24/2011	10:55 AM	Phosphorus - total	ug/l	75	1	Staff	
Ketchum	8/24/2011	10:55 AM	Phosphorus - total	ug/l	328	2	Staff	
Ketchum	8/24/2011	10:55 AM	Phosphorus - total	ug/l	239	4	Staff	
Ketchum	8/24/2011	10:55 AM	Phosphorus - total	ug/l	3620	5	Staff	D
Ketchum	9/13/2011	2:15 AM	Phosphorus - total	ug/l	81	1	Staff	
Ketchum	9/13/2011	2:15 AM	Phosphorus - total	ug/l	424	2	Staff	
Ketchum	9/13/2011	2:15 AM	Phosphorus - total	ug/l	3310	4	Staff	
Ketchum	9/13/2011	2:15 AM	Phosphorus - total	ug/l	3480	5	Staff	
Ketchum	9/28/2011	11:10 AM	Phosphorus - total	ug/l	222	1	Staff	
Ketchum	9/28/2011	11:10 AM	Phosphorus - total	ug/l	235	2	Staff	D

**Lake Ketchum Chemical Data June 2010 - October 2011**

Lake	Date	Hour	Parameter	Units	Value	Depth	Source	Code
Ketchum	9/28/2011	11:10 AM	Phosphorus - total	ug/l	1700	4	Staff	
Ketchum	9/28/2011	11:10 AM	Phosphorus - total	ug/l	3610	5	Staff	
Ketchum	10/12/2011	10:45 AM	Phosphorus - total	ug/l	426	1	Staff	
Ketchum	10/12/2011	10:45 AM	Phosphorus - total	ug/l	411	2	Staff	
Ketchum	10/12/2011	10:45 AM	Phosphorus - total	ug/l	579	4	Staff	
Ketchum	10/12/2011	10:45 AM	Phosphorus - total	ug/l	2480	5	Staff	
Ketchum	10/21/2011	10:30 AM	Phosphorus - total	ug/l	577	1	Staff	
Ketchum	10/21/2011	10:30 AM	Phosphorus - total	ug/l	612	2	Staff	
Ketchum	10/21/2011	10:30 AM	Phosphorus - total	ug/l	618	4	Staff	
Ketchum	10/21/2011	10:30 AM	Phosphorus - total	ug/l	1620	5	Staff	

**Lake Ketchum Inlet Phosphorus Measurements September 2010 - July 2011**

DATE	Total Phosphorus (µg/l)	Soluble Reactive Phosphorus (µg/l)	Code
10/20/2010	625	519	
11/15/2010	679	584	
12/13/2010	777	639	
1/13/2011	669	590 D	
2/17/2011	623	589	
3/17/2011	590	579	
4/11/2011	671	620 D	
4/23/2011	493	309	
5/12/2011	1060	904	
5/24/2011	416	374	
6/7/2011	458	424	
6/22/2011	475	371	
7/13/2011	503	407	



CASE FILE NUMBER: SNO005-20 PAGE 2  
 REPORT DATE: 09/28/10  
 DATE SAMPLED: 09/11-13/10 DATE RECEIVED: 09/13/10  
 FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER  
 SAMPLES FROM SNOHOMISH COUNTY SWM

SAMPLE ID	TOTAL-P (mg/l)	CHLOR_a (ug/l)	PHAEO_a (ug/l)	TRUE COLOR (pcu)
KETCHUM 1M	0.157	7.2	11	45
KETCHUM 5M	2.18			
LOMA 1M	0.090	5.9	5.0	120
LOMA 7M	0.073			
LOST 1M	0.016	7.5	5.2	50
LOST 11M	0.187			
MARTHA N 1M	0.011	4.1	<0.1	25
MARTHA N 19M	0.132			
NINA 1M	0.042			10
NINA 10M	0.079			
PANTHER 1M	0.014	3.8	<0.1	25
PANTHER 10M	0.103			
ROESIGER N 1M	0.009	2.7	1.8	10
ROESIGER N 30M	0.027			
RUGGS 1M	0.058			45
RUGGS 3M	0.054			
SERENE 1M	0.013	2.7	1.4	20
SERENE 5M	0.012			
SHOECRAFT A 1m	0.012	4.5	1.6	15
SHOECRAFT B 7m	0.032			
STICKNEY 1M	0.020	4.8	2.9	35
STICKNEY 9M	0.445			
STORM 1M	0.009	4.0	1.4	25
STORM 12M	0.047			
SUNDAY BOAT LAUNCH	0.029			35
SUNDAY A 1m	0.038	14	6.9	
SUNDAY B 4.5m	0.042			
WAGNER 1M	0.022	2.7	2.7	20
WAGNER 5M	0.034			





## LABORATORY &amp; CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER: SNO005-20 PAGE 3  
 REPORT DATE: 09/28/10  
 DATE SAMPLED: 09/11-23/10 DATE RECEIVED: 09/13/10  
 FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER  
 SAMPLES FROM SNOHOMISH COUNTY SWM

## QA/QC DATA

QC PARAMETER	TOTAL-P (mg/l)	TOTAL-P (mg/l)	CHLOR <sub>a</sub> (ug/l)	PHAEO <sub>a</sub> (ug/l)	TRUE COLOR (pcu)
METHOD	SM18 4500PF	SM18 4500PF	SM18 10200H	SM18 10200H	EPA 110.2
DATE PREPARED	09/16/10	09/16/10	09/14/10	09/14/10	
DATE ANALYZED	09/20/10	09/20/10	09/27/10	09/27/10	09/15/10
DETECTION LIMIT	0.002	0.002	0.1	0.1	5
DUPLICATE					
SAMPLE ID	KAYAK 1M	WAGNER 5M	WAGNER 1M	WAGNER 1M	
ORIGINAL	0.020	0.034	2.7	2.7	
DUPLICATE	0.021	0.035	3.0	2.6	
RPD	5.95%	2.98%	11.76%	3.77%	NA
SPIKE SAMPLE					
SAMPLE ID	KAYAK 1M	WAGNER 5M			
ORIGINAL	0.020	0.034			
SPIKED SAMPLE	0.068	0.087			
SPIKE ADDED	0.050	0.050			
% RECOVERY	97.68%	106.67%	NA	NA	NA
QC CHECK					
FOUND	0.092	0.092			
TRUE	0.090	0.090			
% RECOVERY	102.52%	102.52%	NA	NA	NA
BLANK	<0.002	<0.002	NA	NA	<5

RPD = RELATIVE PERCENT DIFFERENCE.

NA = NOT APPLICABLE OR NOT AVAILABLE.

NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.

OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

 Steven Lazoff  
 Laboratory Director



SHEET 4 OF 7

CLIENT: **CHAIN-OF-CUSTODY RECORD** Snohomish County - SWM  
 SAMPLING DATE: \_\_\_\_\_  
 SAMPLERS: Volunteers

PROJECT ID: Lakes  
CASE FILE NO.:  
DATA RECORDED BY:

### SAMPLE INFORMATION

## PARAMETERS

SAMPLE ID	DATE/TIME COLLECTED	TP	Chlorophyll a	True Color	BOTT #	NOTES
Ketchum - 1m	9/12/10	X	X	y	3	
Ketchum - 5m	1:30pm	x			7	
Ki - 1m						
Ki - 18 m						
Loma - 1m	9/12/10	X	X	X	3	
Loma - 7m	10:00 AM	X			1	
Lost - 1m	9/12/10 12:00	X	X	X	3	
Lost - 11m	" "	X			1	
Martha N - 1m	9/12/10	X	X	X	3	
Martha N - 19m	10:00AM	X			1	

Relinquished By	Date/Time	Received By	Date/Time
Printed Name			
Signature			
Affiliation	Snohomish County - SWM		

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name				
Signature				
Affiliation				

Miscellaneous Notes (Hazardous Materials, Quick turn-around time, etc.): Ketchum 18 m values may be high

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<b>CASE FILE NUMBER:</b>	<b>SNO005-26</b>	<b>PAGE 1</b>
<b>REPORT DATE:</b>	<b>10/28/10</b>	
<b>DATE SAMPLED:</b>	<b>10/20/10</b>	<b>DATE RECEIVED: 10/20/10</b>
<b>FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER</b>		
<b>SAMPLES FROM SNOHOMISH COUNTY SWM</b>		

**CASE NARRATIVE**

Five samples were delivered to the laboratory in good condition. The samples were analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on subsequent pages.

**SAMPLE DATA**

SAMPLE ID	TOTAL-P (mg/l)	SRP (mg/l)	CHLOR_a (ug/l)	PHAEO_a (ug/l)
KETCHUM 1M	0.459	0.276	42	9.8
KETCHUM 2M	0.412	0.281		
KETCHUM 4M	0.433	0.289		
KETCHUM 5M	0.522	0.368		
INLET CULVERT	0.625	0.519		

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<b>CASE FILE NUMBER:</b>	<b>SNO005-26</b>	<b>PAGE 2</b>
<b>REPORT DATE:</b>	<b>10/28/10</b>	
<b>DATE SAMPLED:</b>	<b>10/20/10</b>	<b>DATE RECEIVED: 10/20/10</b>
<b>FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER</b>		
<b>SAMPLES FROM SNOHOMISH COUNTY SWM</b>		

**QA/QC DATA**

QC PARAMETER	TOTAL-P (mg/l)	SRP (mg/l)	CHLOR_a (ug/l)	PHAEO_a (ug/l)
METHOD	SM18 4500PF	SM18 4500PF	SM18 10200H	SM18 10200H
DATE PREPARED	10/21/10		10/21/10	10/21/10
DATE ANALYZED	10/22/10	10/21/10	10/25/10	10/25/10
DETECTION LIMIT	0.002	0.001	0.1	0.1
DUPLICATE				
SAMPLE ID	INLET CULVERT	BATCH	BATCH	BATCH
ORIGINAL	0.625	<0.001	5.3	2.7
DUPLICATE	0.631	<0.001	4.5	2.4
RPD	1.06%	NC	16.22%	11.64%
SPIKE SAMPLE				
SAMPLE ID	INLET CULVERT	BATCH		
ORIGINAL	0.625	<0.001		
SPIKED SAMPLE	0.677	0.019		
SPIKE ADDED	0.050	0.020		
% RECOVERY	103.74%	92.72%	NA	NA
QC CHECK				
FOUND	0.091	0.033		
TRUE	0.090	0.033		
% RECOVERY	101.57%	99.56%	NA	NA
BLANK	<0.002	<0.001	NA	NA

RPD = RELATIVE PERCENT DIFFERENCE

NA = NOT APPLICABLE OR NOT AVAILABLE

NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT

OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION

SUBMITTED BY:

Steven Lazoff  
Laboratory Director



**Aquatic Research Incorporated**

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5/10/05.26

## CHAIN-OF-CUSTODY RECORD

CLIENT: Snohomish County - SWM  
SAMPLING DATE: 10/20/10  
SAMPLERS: K. Polver

SHEET 1 OF 1  
PROJECT ID: Laice Ketchum  
CASE FILE NO.: \_\_\_\_\_  
DATA RECORDED BY: \_\_\_\_\_

## SAMPLE INFORMATION

[illegible]

Printed Name	Relinquished By	Date/Time	Received By	Date/Time
Signature	<i>Katherine Lehner</i>	10/20/10	<i>S. HILGSON</i>	10/20/10
Affiliation	ShoCo - SWM	14:20	<i>BL</i>	14:20
			<i>A.M.</i>	

Printed Name	Relinquished By	Date/Time	Received By	Date/Time
Signature				
Affiliation				

Miscellaneous Notes (Hazardous Materials, Quick turn-around time, etc.):



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ent.  
MB ✓

<b>CASE FILE NUMBER:</b>	<b>SNO005-29</b>	<b>PAGE 1</b>
<b>REPORT DATE:</b>	<b>11/24/10</b>	
<b>DATE SAMPLED:</b>	<b>11/15/10</b>	<b>DATE RECEIVED:</b> <b>11/15/10</b>
<b>FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER</b>		
<b>SAMPLES FROM SNOHOMISH COUNTY SWM</b>		

**CASE NARRATIVE**

Six samples were delivered to the laboratory in good condition. The samples were analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on subsequent pages.

**SAMPLE DATA**

SAMPLE ID	TOTAL-P (mg/l)	SRP (mg/l)	CHLOR_a (ug/l)	PHAEO_a (ug/l)
KETCHUM 1M	0.444	0.286	10	7.4
KETCHUM 2M	0.441	0.310		
KETCHUM 4M	0.458	0.315		
KETCHUM 5M	0.456	0.325		
KETCHUM INLET1	0.679 ✓	0.584 ✓		
KETCHUM 308TH	1.88 ✓	1.41 ✓		

AMJ  
MB

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<b>CASE FILE NUMBER:</b>	<b>SNO005-29</b>	<b>PAGE 2</b>
<b>REPORT DATE:</b>	<b>11/24/10</b>	
<b>DATE SAMPLED:</b>	<b>11/15/10</b>	<b>DATE RECEIVED: 11/15/10</b>
<b>FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER</b>		
<b>SAMPLES FROM SNOHOMISH COUNTY SWM</b>		

**QA/QC DATA**

QC PARAMETER	TOTAL-P (mg/l)	SRP (mg/l)	CHLOR_a (ug/l)	PHAEO_a (ug/l)
METHOD	SM18 4500PF	SM18 4500PF	SM18 10200H	SM18 10200H
DATE PREPARED	11/18/10		11/16/10	11/16/10
DATE ANALYZED	11/22/10	11/16/10	11/16/10	11/16/10
DETECTION LIMIT	0.002	0.001	0.1	0.1
DUPLICATE				
SAMPLE ID	BATCH	BATCH	BATCH	BATCH
ORIGINAL	0.039	0.002	1.6	2.9
DUPLICATE	0.039	0.002	1.6	2.5
RPD	1.10%	1.95%	0.00%	13.86%
SPIKE SAMPLE				
SAMPLE ID	BATCH	BATCH		
ORIGINAL	0.039	0.002		
SPIKED SAMPLE	0.086	0.023		
SPIKE ADDED	0.050	0.020		
% RECOVERY	93.86%	101.52%	NA	NA
QC CHECK				
FOUND	0.090	0.033		
TRUE	0.090	0.033		
% RECOVERY	99.51%	100.69%	NA	NA
BLANK	<0.002	<0.001	NA	NA

RPD = RELATIVE PERCENT DIFFERENCE.

NA = NOT APPLICABLE OR NOT AVAILABLE.

NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.

QR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Steven Lazoff

Laboratory Director

SN0005-29



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SHEET 1 OF 1

CLIENT: **CHAIN-OF-CUSTODY RECORD** Snohomish County - SWM

**SAMPLING DATE:**

SAMPLERS: K. Rohrer, G. Williams

PROJECT ID: Lakes Lake Ketchum

CASE FILE NO.:

DATA RECORDED BY:

### SAMPLE INFORMATION

## PARAMETERS

[illegible]

Printed Name	* Kato Rohrer	Date/Time	* 11/15/10	Received By	S. J. [Signature]	Date/Time	11/15/10
Signature	* [Signature]		15:00		[Signature]		1500
Affiliation	Snohomish County - Volunteer				[Signature]		

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name				
Signature				
Affiliation				

Miscellaneous Notes (Hazardous Materials, Quick turn-around time, etc.):

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MB  
gmw

<b>CASE FILE NUMBER:</b>	<b>SNO005-32</b>	<b>PAGE 1</b>
<b>REPORT DATE:</b>	<b>12/23/10</b>	
<b>DATE SAMPLED:</b>	<b>12/13/10</b>	<b>DATE RECEIVED:</b>
		<b>12/13/10</b>
<b>FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER</b>		
<b>SAMPLES FROM SNOHOMISH COUNTY SWM</b>		

**CASE NARRATIVE**

Six samples were delivered to the laboratory in good condition. The samples were analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on subsequent pages.

**SAMPLE DATA**

SAMPLE ID	TOTAL-P (mg/l)	SRP (mg/l)	CHLOR a (ug/l)	PHAEO a (ug/l)
KETCHUM 1M	0.398	0.221	23	8.3
KETCHUM 2M	0.399	0.238		
KETCHUM 4M	0.400	0.236		
KETCHUM 5M	0.405	0.250		
KETCHUM INLET1	0.777	0.639		
KETCHUM 308TH	1.39	1.23		

MB

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<b>CASE FILE NUMBER:</b>	SNO005-32	<b>PAGE 2</b>
<b>REPORT DATE:</b>	12/23/10	
<b>DATE SAMPLED:</b>	12/13/10	<b>DATE RECEIVED:</b> 12/13/10
<b>FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER</b>		
<b>SAMPLES FROM SNOHOMISH COUNTY SWM</b>		

**QA/QC DATA**

QC PARAMETER	TOTAL-P (mg/l)	SRP (mg/l)	CHLOR_a (ug/l)	PHAEO_a (ug/l)
METHOD	SM18 4500PF	SM18 4500PF	SM18 10200H	SM18 10200H
DATE PREPARED	12/15/10		12/14/10	12/14/10
DATE ANALYZED	12/16/10	12/15/10	12/20/10	12/20/10
DETECTION LIMIT	0.002	0.001	0.1	0.1
DUPLICATE				
SAMPLE ID	BATCH	BATCH	KETCHUM 1M	KETCHUM 1M
ORIGINAL	0.103	0.004	23	8.3
DUPLICATE	0.105	0.004	26	8.6
RPD	2.42 %	1.58 %	10.75 %	3.80 %
SPIKE SAMPLE				
SAMPLE ID	BATCH	BATCH		
ORIGINAL	0.103	0.004		
SPIKED SAMPLE	0.149	0.024		
SPIKE ADDED	0.050	0.020		
% RECOVERY	92.79 %	101.05 %	NA	NA
QC CHECK				
FOUND	0.089	0.033		
TRUE	0.090	0.033		
% RECOVERY	99.31 %	101.04 %	NA	NA
BLANK	<0.002	<0.001	NA	NA

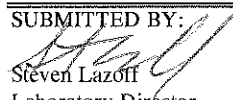
RPD = RELATIVE PERCENT DIFFERENCE.

NA = NOT APPLICABLE OR NOT AVAILABLE.

INC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.

ROR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

  
 Steven Lazoff  
 Laboratory Director



CLIENT: Sno Co - SWM

SAMPLING DATE: 12/13/10

SAMPLERS: K. Rohrer

SAMPLERS: K. Rohrer; G. Williams

SHEET 1 OF 1

PROJECT ID: Lake Ketchikan

CASE FILE NO.:

DATA RECORDED BY:

## PARAMETERS

[illegible]

Printed Name	Relinquished By	Date/Time	Received By	Date/Time
Signature				
Affiliation				

Printed Name	Relinquished By	Date/Time	Received By	Date/Time
Signature				
Affiliation				

Miscellaneous Notes (Hazardous Materials, Quick turn-around time, etc.):

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<b>CASE FILE NUMBER:</b>	<b>SNO005-36</b>	<b>PAGE 1</b>
<b>REPORT DATE:</b>	<b>01/25/11</b>	
<b>DATE SAMPLED:</b>	<b>01/13/11</b>	<b>DATE RECEIVED: 01/14/11</b>
<b>FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER</b>		
<b>SAMPLES FROM SNOHOMISH COUNTY SWM</b>		

**CASE NARRATIVE**

Eight samples were delivered to the laboratory in good condition. The samples were analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on subsequent pages.

**SAMPLE DATA**

SAMPLE ID	TOTAL-P (mg/l)	SRP (mg/l)	CHLOR_a (ug/l)	PHAEO_a (ug/l)
KETCHUM 1M	0.344	0.205	11	6.0
KETCHUM 1M DUPE	0.358	0.213	10	6.3
KETCHUM 2M	0.343	0.215		
KETCHUM 4M	0.346	0.221		
KETCHUM 5M	0.347	0.218		
KETCHUM INLET1	0.663	0.586		
KETCHUM INLET DUPE	0.675	0.593		
KETCHUM 308TH	1.34	1.33		

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<b>CASE FILE NUMBER:</b>	<b>SNO005-36</b>	<b>PAGE 2</b>
<b>REPORT DATE:</b>	<b>01/25/11</b>	
<b>DATE SAMPLED:</b>	<b>01/13/11</b>	<b>DATE RECEIVED: 01/14/11</b>
<b>FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER</b>		
<b>SAMPLES FROM SNOHOMISH COUNTY SWM</b>		

**QA/QC DATA**

QC PARAMETER	TOTAL-P (mg/l)	SRP (mg/l)	CHLOR_a (ug/l)	PHAEO_a (ug/l)
METHOD	SM18 4500PF	SM18 4500PF	SM18 10200H	SM18 10200H
DATE PREPARED	01/14/11		01/14/11	01/14/11
DATE ANALYZED	01/17/11	01/14/11	01/24/11	01/24/11
DETECTION LIMIT	0.002	0.001	0.1	0.1
DUPLICATE				
SAMPLE ID	BATCH	BATCH	KETCHUM 1M DUPE	KETCHUM 1M DUPE
ORIGINAL	0.020	0.005	10	6.3
DUPLICATE	0.019	0.005	9.1	5.5
RPD	3.35%	10.14%	11.11%	13.57%
SPIKE SAMPLE				
SAMPLE ID	BATCH	BATCH		
ORIGINAL	0.020	0.005		
SPIKED SAMPLE	0.070	0.025		
SPIKE ADDED	0.050	0.020		
% RECOVERY	99.83%	100.93%	NA	NA
QC CHECK				
FOUND	0.093	0.033		
TRUE	0.090	0.033		
% RECOVERY	102.98%	100.12%	NA	NA
BLANK	<0.002	<0.001	NA	NA

RPD = RELATIVE PERCENT DIFFERENCE.

NA = NOT APPLICABLE OR NOT AVAILABLE.

NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.

OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Steven Lazoff  
Laboratory Director

SINAPPOS June 2012 36



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SHEET 1 OF 1

CLIENT: ~~CHAIN OF CUSTODY RECORD~~ Snohomish County - SWM

SAMPLING DATE: January 13, 2011

SAMPLERS: G. Williams, M. Burchdoff

PROJECT ID: ~~Lake Stevens~~ Lake Kootenai

CASE FILE NO.:

DATA RECORDED BY:

## SAMPLE INFORMATION

## PARAMETERS

[illegible]

Printed Name	Relinquished By <sup>1</sup> <i>Gene Williams</i>	Date/Time <i>1/14/11 7am</i>	Received By <i>Nina Williams</i>	Date/Time <i>1/14/11 7am</i>
Signature	<i>Gene N. Williams</i>	<i>11</i>	<i>X Nina Williams</i>	<i>11</i>
Affiliation	Snohomish County - SWM			

Printed Name	Relinquished By <i>Nina Williams</i>	Date/Time <i>1/14/11 8:50 x</i>	Received By <i>Olga Anatalayev</i>	Date/Time <i>1/14/11</i>
Signature	<i>x Nina Williams</i>	<i>1/14/11 8:50am</i>	<i>[Signature]</i>	<i>8:50 am</i>
Affiliation				

Miscellaneous Notes (Hazardous Materials, Quick turn-around time, etc.):

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<b>CASE FILE NUMBER:</b>	<b>SNO005-39</b>	<b>PAGE 1</b>
<b>REPORT DATE:</b>	<b>02/28/11</b>	
<b>DATE SAMPLED:</b>	<b>02/17/11</b>	<b>DATE RECEIVED: 02/18/11</b>
<b>FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER</b>		
<b>SAMPLES FROM SNOHOMISH COUNTY SWM</b>		

**CASE NARRATIVE**

Six samples were delivered to the laboratory in good condition. The samples were analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on subsequent pages.

**SAMPLE DATA**

SAMPLE ID	TOTAL-P (mg/l)	SRP (mg/l)	CHLOR_a (ug/l)	PHAEO_a (ug/l)
KETCHUM-1M	0.266	0.141	8.0	2.1
KETCHUM-2M	0.277	0.146		
KETCHUM-4M	0.251	0.190		
KETCHUM-5M	0.259	0.153		
KETCHUM-308TH	2.26	1.94		
KETCHUM-INLET1	0.623	0.589		

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<b>CASE FILE NUMBER:</b>	SNO005-39	<b>PAGE 2</b>
<b>REPORT DATE:</b>	02/28/11	
<b>DATE SAMPLED:</b>	02/17/11	<b>DATE RECEIVED:</b> 02/18/11
<b>FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER</b>		
<b>SAMPLES FROM SNOHOMISH COUNTY SWM</b>		

**QA/QC DATA**

QC PARAMETER	TOTAL-P (mg/l)	SRP (mg/l)	CHLOR_a (ug/l)	PHAEO_a (ug/l)
METHOD	SM18 4500PF	SM18 4500PF	SM18 10200H	SM18 10200H
DATE PREPARED	02/24/11		02/18/11	02/18/11
DATE ANALYZED	02/24/11	02/18/11	02/23/11	02/23/11
DETECTION LIMIT	0.002	0.001	0.1	0.1
DUPLICATE				
SAMPLE ID	BATCH	BATCH	KETCHUM-1M	KETCHUM-1M
ORIGINAL	0.031	0.007	8.0	2.1
DUPLICATE	0.031	0.007	8.5	2.5
RPD	1.51%	4.71%	6.45%	17.54%
SPIKE SAMPLE				
SAMPLE ID	BATCH	BATCH		
ORIGINAL	0.031	0.007		
SPIKED SAMPLE	0.080	0.027		
SPIKE ADDED	0.050	0.020		
% RECOVERY	97.27%	98.84%	NA	NA
QC CHECK				
FOUND	0.090	0.033		
TRUE	0.090	0.033		
% RECOVERY	100.13%	100.49%	NA	NA
BLANK	<0.002	<0.001	NA	NA

RPD = RELATIVE PERCENT DIFFERENCE.

NA = NOT APPLICABLE OR NOT AVAILABLE.

NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.

OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Steven Lazoff  
Laboratory Director



3927 Aurora Ave. N / Seattle, WA 98103 / (206) 632-2715

SAMPLERS: G. Williams, M. Burghdoff

DATA RECORDED BY:

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<b>CASE FILE NUMBER:</b>	<b>SNO005-42</b>	<b>PAGE 1</b>
<b>REPORT DATE:</b>	<b>03/29/11</b>	
<b>DATE SAMPLED:</b>	<b>03/17/11</b>	<b>DATE RECEIVED: 03/18/11</b>
<b>FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER</b>		
<b>SAMPLES FROM SNOHOMISH COUNTY SWM</b>		

**CASE NARRATIVE**

Six samples were delivered to the laboratory in good condition. The samples were analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on subsequent pages.

**SAMPLE DATA**

SAMPLE ID	TOTAL-P (mg/l)	SRP (mg/l)	CHLOR_a (ug/l)	PHAEO_a (ug/l)
KETCHUM 1M	0.188	0.112	20	0.8
KETCHUM 2M	0.174	0.117		
KETCHUM 4M	0.176	0.120		
KETCHUM 5M	0.188	0.119		
KETCHUM INLET	0.590	0.579		
KETCHUM 308TH	1.46	1.27		



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<b>CASE FILE NUMBER:</b>	SNO005-42	<b>PAGE 2</b>
<b>REPORT DATE:</b>	03/29/11	
<b>DATE SAMPLED:</b>	03/17/11	<b>DATE RECEIVED:</b> 03/18/11
<b>FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER</b>		
<b>SAMPLES FROM SNOHOMISH COUNTY SWM</b>		

**QA/QC DATA**

QC PARAMETER	TOTAL-P (mg/l)	SRP (mg/l)	CHLOR_a (ug/l)	PHAEO_a (ug/l)
METHOD	SM18 4500PF	SM18 4500PF	SM18 10200H	SM18 10200H
DATE PREPARED	03/21/11		03/18/11	03/18/11
DATE ANALYZED	03/22/11	03/18/11	03/24/11	03/24/11
DETECTION LIMIT	0.002	0.001	0.1	0.1
DUPLICATE				
SAMPLE ID	BATCH	BATCH	BATCH	BATCH
ORIGINAL	0.013	0.007	4.8	3.0
DUPLICATE	0.013	0.008	5.3	3.3
RPD	1.96%	2.33%	10.53%	6.78%
SPIKE SAMPLE				
SAMPLE ID	BATCH	BATCH		
ORIGINAL	0.013	0.007		
SPIKED SAMPLE	0.063	0.027		
SPIKE ADDED	0.050	0.020		
% RECOVERY	99.72%	97.79%	NA	NA
QC CHECK				
FOUND	0.092	0.032		
TRUE	0.090	0.033		
% RECOVERY	101.84%	96.61%	NA	NA
BLANK	<0.002	<0.001	NA	NA

RPD = RELATIVE PERCENT DIFFERENCE.

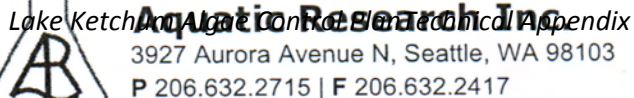
NA = NOT APPLICABLE OR NOT AVAILABLE.

NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.

OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Steven Lazoff  
Laboratory Director



CLIENT: **CHAIN-OF-CUSTODY-RECORD** Snohomish County - SWM  
SAMPLING DATE: \* March 17, 2011  
SAMPLERS: \* G. Williams M. Burghdoff

PROJECT ID: Lakes/Ketchum  
CASE FILE NO.: \_\_\_\_\_  
DATA RECORDED BY: \_\_\_\_\_

## SAMPLE INFORMATION

## PARAMETERS

[illegible]

Printed Name	Relinquished By • Gene Williams	Date/Time • 3/18/11 7:00	Received By Nina Williams	Date/Time 3/18/11 7:00
Signature	• Gene Williams		Nina Williams	
Affiliation	Snohomish County - Volunteer			

Printed Name	Relinquished By <i>Nina Williams</i>	Date/Time <i>3/18/11</i> <i>(8:00)</i>	Received By <i>John S. Galloway</i>	Date/Time <i>3/18/11</i> <i>8:00</i>
Signature	<i>Nina Williams</i> X		<i>John S. Galloway</i>	
Affiliation			<i>AR</i>	

Miscellaneous Notes (Hazardous Materials, Quick turn-around time, etc.):

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<b>CASE FILE NUMBER:</b>	<b>SNO005-45</b>	<b>PAGE 1</b>
<b>REPORT DATE:</b>	<b>04/20/11</b>	
<b>DATE SAMPLED:</b>	<b>04/11/11</b>	<b>DATE RECEIVED: 04/11/11</b>
<b>FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER</b>		
<b>SAMPLES FROM SNOHOMISH COUNTY SWM</b>		

**CASE NARRATIVE**

Eight samples were delivered to the laboratory in good condition. The samples were analyzed according to the chain of custody. Samples for True Color were filtered through a 0.45 um nylon filter before analysis. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on subsequent pages.

**SAMPLE DATA**

SAMPLE ID	TOTAL-P (mg/l)	SRP (mg/l)	CHLOR_a (ug/l)	PHAEO_a (ug/l)	TRUE COLOR (pcu)
KETCHUM-1M	0.150	0.074	65	6.4	80
KETCHUM-1M DUPE	0.186	0.076	59	5.8	
KETCHUM-2M	0.167	0.078			
KETCHUM-4M	0.205	0.126			
KETCHUM-5M	0.355	0.251			
KETCHUM-INLET	0.682	0.618			
KETCHUM-INLET DUPE	0.660	0.622			
KETCHUM-308TH	2.34	2.25			

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<b>CASE FILE NUMBER:</b>	SNO005-45	<b>PAGE 2</b>
<b>REPORT DATE:</b>	04/20/11	
<b>DATE SAMPLED:</b>	04/11/11	<b>DATE RECEIVED:</b> 04/11/11
<b>FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER</b>		
<b>SAMPLES FROM SNOHOMISH COUNTY SWM</b>		

**QA/QC DATA**

QC PARAMETER	TOTAL-P (mg/l)	SRP (mg/l)	CHLOR_a (ug/l)	PHAEO_a (ug/l)	TRUE COLOR (pcu)
METHOD	SM18 4500PF	SM18 4500PF	SM18 10200H	SM18 10200H	EPA 110.2
DATE PREPARED	04/18/11		04/12/11	04/12/11	
DATE ANALYZED	04/19/11	04/12/11	04/18/11	04/18/11	04/12/11
DETECTION LIMIT	0.002	0.001	0.1	0.1	5
DUPLICATE					
SAMPLE ID	BATCH	BATCH	BATCH	BATCH	
ORIGINAL	0.027	0.002	13	2.1	
DUPLICATE	0.028	0.002	14	2.0	
RPD	3.94%	4.63%	11.76%	5.13%	NA
SPIKE SAMPLE					
SAMPLE ID	BATCH	BATCH			
ORIGINAL	0.027	0.002			
SPIKED SAMPLE	0.073	0.022			
SPIKE ADDED	0.050	0.020			
% RECOVERY	91.54%	98.69%	NA	NA	NA
QC CHECK					
FOUND	0.091	0.033			
TRUE	0.090	0.033			
% RECOVERY	101.56%	99.20%	NA	NA	NA
BLANK	<0.002	<0.001	NA	NA	<5

RPD = RELATIVE PERCENT DIFFERENCE.

NA = NOT APPLICABLE OR NOT AVAILABLE.

NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.

OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Steven Lazoff  
Laboratory Director



5K10005.45  
June 2012

## CHAIN-OF-CUSTODY RECORD

CLIENT: Snohomish County SWM  
SAMPLING DATE: April 11, 2011  
SAMPLERS: G. Williams, M. Burghdoff

SHEET 1 OF 1  
PROJECT ID: Lake Ketihran  
CASE FILE NO.:   
DATA RECORDED BY:

## SAMPLE INFORMATION

[illegible]

Printed Name	Relinquished By <u>Gene Williams</u>	Date/Time <u>15:30 4/11/11</u>	Received By <u>Olga Anjalaryan</u>	Date/Time <u>4/11/11 15:30</u>
Signature	<u>[Signature]</u>		<u>[Signature]</u>	
Affiliation	<u>Sno Co Sheriff</u>		<u>ART</u>	

Printed Name	Relinquished By	Date/Time	Received By	Date/Time
Signature				
Affiliation				

Miscellaneous Notes (Hazardous Materials, Quick turn-around time, etc.):

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<b>CASE FILE NUMBER:</b>	<b>SNO005-47</b>	<b>PAGE 1</b>
<b>REPORT DATE:</b>	<b>05/03/11</b>	
<b>DATE SAMPLED:</b>	<b>04/23/11</b>	<b>DATE RECEIVED: 04/26/11</b>
<b>FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER</b>		
<b>SAMPLES FROM SNOHOMISH COUNTY SWM</b>		

**CASE NARRATIVE**

Seven samples were delivered to the laboratory in good condition. The samples were analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on subsequent pages.

**SAMPLE DATA**

SAMPLE ID	TOTAL-P (mg/l)	SRP (mg/l)	CHLOR_a (ug/l)	PHAEO_a (ug/l)
KETCHUM-1M	0.127	0.020	52	7.3
KETCHUM-2M	0.124	0.022		
KETCHUM-2M-DUP	0.126	0.023		
KETCHUM-4M	0.134	0.036		
KETCHUM-5M	0.631	0.427		
KETCHUM-INLET	0.493	0.309		
KETCHUM-308TH	2.05	1.68		



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<b>CASE FILE NUMBER:</b>	SNO005-47	<b>PAGE 2</b>
<b>REPORT DATE:</b>	05/03/11	
<b>DATE SAMPLED:</b>	04/23/11	<b>DATE RECEIVED:</b> 04/26/11
<b>FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER</b>		
<b>SAMPLES FROM SNOHOMISH COUNTY SWM</b>		

**QA/QC DATA**

QC PARAMETER	TOTAL-P (mg/l)	SRP (mg/l)	CHLOR_a (ug/l)	PHAEO_a (ug/l)
METHOD	SM18 4500PF	SM18 4500PF	SM18 10200H	SM18 10200H
DATE PREPARED	04/28/11		04/26/11	04/26/11
DATE ANALYZED	05/02/11	04/26/11	04/29/11	04/29/11
DETECTION LIMIT	0.002	0.001	0.1	0.1
DUPLICATE				
SAMPLE ID	KETCHUM-1M	KETCHUM-1M	KETCHUM-1M	KETCHUM-1M
ORIGINAL	0.127	0.020	52	7.3
DUPLICATE	0.126	0.021	53	6.6
RPD	0.81%	2.47%	2.04%	10.04%
SPIKE SAMPLE				
SAMPLE ID	KETCHUM-1M	KETCHUM-1M		
ORIGINAL	0.127	0.020		
SPIKED SAMPLE	0.175	0.039		
SPIKE ADDED	0.050	0.020		
% RECOVERY	97.75%	94.20%	NA	NA
QC CHECK				
FOUND	0.090	0.033		
TRUE	0.090	0.033		
% RECOVERY	99.96%	101.46%	NA	NA
BLANK	<0.002	<0.001	NA	NA

RPD = RELATIVE PERCENT DIFFERENCE.

NA = NOT APPLICABLE OR NOT AVAILABLE.

NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.

OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION

SUBMITTED BY:

Steven Lazoff  
 Laboratory Director



SHEET 1 OF 1

CLIENT: **CHAIN-OF-CUSTODY RECORD** Snohomish County - SWM  
SAMPLING DATE: \_\_\_\_\_

SAMPLING DATE: \_\_\_\_\_

**SAMPLERS:** \_\_\_\_\_

PROJECT ID: Ketchum

CASE FILE NO.:

DATA RECORDED BY:

## SAMPLE INFORMATION

[illegible]

Printed Name	Relinquished By Nansa Berghdott	Date/Time	Received By	Date/Time
Signature	<i>[Signature]</i>	4/21/11 9:19	<i>[Signature]</i>	4/26/11 0918
Affiliation	Snohomish County - SWM		ARC	

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name				
Signature				
Affiliation				

Miscellaneous Notes (Hazardous Materials, Quick turn-around time, etc.):



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<b>CASE FILE NUMBER:</b>	<b>SNO005-48</b>	<b>PAGE 1</b>
<b>REPORT DATE:</b>	<b>05/27/11</b>	
<b>DATE SAMPLED:</b>	<b>05/12/11</b>	<b>DATE RECEIVED: 05/13/11</b>
<b>FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER</b>		
<b>SAMPLES FROM SNOHOMISH COUNTY SWM</b>		

**CASE NARRATIVE**

Seven samples were delivered to the laboratory in good condition. The samples were analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on subsequent pages.

**SAMPLE DATA**

SAMPLE ID	TOTAL-P (mg/l)	SRP (mg/l)	CHLOR_a (ug/l)	PHAEO_a (ug/l)
KETCHUM-1M	0.127	0.033	36	6.3
KETCHUM-2M	0.130	0.047		
KETCHUM-4M	0.347	0.276		
KETCHUM-4M DUPE	0.342	0.247		
KETCHUM-5M	1.55	0.915		
KETCHUM INLET	1.06	0.904		
KETCHUM 308TH	2.40	2.20		



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<b>CASE FILE NUMBER:</b>	<b>SNO005-48</b>	<b>PAGE 2</b>
<b>REPORT DATE:</b>	<b>05/27/11</b>	
<b>DATE SAMPLED:</b>	<b>05/12/11</b>	<b>DATE RECEIVED: 05/13/11</b>
<b>FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER</b>		
<b>SAMPLES FROM SNOHOMISH COUNTY SWM</b>		

**QA/QC DATA**

QC PARAMETER	TOTAL-P (mg/l)	SRP (mg/l)	CHLOR_a (ug/l)	PHAE0_a (ug/l)
METHOD	SM18 4500PF	SM18 4500PF	SM18 10200H	SM18 10200H
DATE PREPARED	05/19/11		05/13/11	05/13/11
DATE ANALYZED	05/23/11	05/13/11	05/25/11	05/25/11
DETECTION LIMIT	0.002	0.001	0.1	0.1
DUPLICATE				
SAMPLE ID	BATCH	KETCHUM-1M	BATCH	BATCH
ORIGINAL	0.043	0.033	4.8	0.8
DUPLICATE	0.044	0.034	4.8	0.8
RPD	1.54%	2.74%	0.00%	0.00%
SPIKE SAMPLE				
SAMPLE ID	BATCH	KETCHUM-1M		
ORIGINAL	0.043	0.033		
SPIKED SAMPLE	0.092	0.054		
SPIKE ADDED	0.050	0.020		
% RECOVERY	97.26%	104.92%	NA	NA
QC CHECK				
FOUND	0.092	0.033		
TRUE	0.090	0.033		
% RECOVERY	101.72%	99.87%	NA	NA
BLANK	<0.002	<0.001	NA	NA

RPD = RELATIVE PERCENT DIFFERENCE.

NA = NOT APPLICABLE OR NOT AVAILABLE.

NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.

OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION

SUBMITTED BY:

Steven Lazoff  
 Laboratory Director

P 206.632.2715 | F 206.632.2417

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SHEET 1 OF 1

SAMPLERS: G. Williams M. Burghoff

DATA RECORDED BY:

## PARAMETERS

[illegible]

Printed Name	Relinquished By <i>Gene Williams</i>	Date/Time <i>5/13/11 8:25</i>	Received By <i>S. Williams</i>	Date/Time <i>5/13/11</i>
Signature	<i>Gene Williams</i>		<i>[Signature]</i>	<i>0825</i>
Affiliation	Snohomish County - SWM		<i>[Signature]</i>	

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name				
Signature				
Affiliation				

Miscellaneous Notes (Hazardous Materials, Quick turn-around time, etc.):

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<b>CASE FILE NUMBER:</b>	<b>SNO005-51</b>	<b>PAGE 1</b>
<b>REPORT DATE:</b>	<b>06/02/11</b>	
<b>DATE SAMPLED:</b>	<b>05/24/11</b>	<b>DATE RECEIVED: 05/25/11</b>
<b>FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER</b>		
<b>SAMPLES FROM SNOHOMISH COUNTY SWM</b>		

**CASE NARRATIVE**

Seven samples were delivered to the laboratory in good condition. The samples were analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on subsequent pages.

**SAMPLE DATA**

SAMPLE ID	TOTAL-P (mg/l)	SRP (mg/l)	CHLOR_a (ug/l)	PHAEO_a (ug/l)
KETCHUM-1M	0.135	0.022	64	9.6
KETCHUM-2M	0.167	0.110		
KETCHUM-4M	0.775	0.566		
KETCHUM-5M	1.66	1.22		
KETCHUM-5M DUPE	1.73	1.28		
KETCHUM-INLET1	0.416	0.374		
KETCHUM-308TH	2.57	2.11		



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<b>CASE FILE NUMBER:</b>	SNO005-51	<b>PAGE 2</b>
<b>REPORT DATE:</b>	06/02/11	
<b>DATE SAMPLED:</b>	05/24/11	<b>DATE RECEIVED:</b> 05/25/11
<b>FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER</b>		
<b>SAMPLES FROM SNOHOMISH COUNTY SWM</b>		

**QA/QC DATA**

QC PARAMETER	TOTAL-P (mg/l)	SRP (mg/l)	CHLOR_a (ug/l)	PHAE0_a (ug/l)
METHOD	SM18 4500PF	SM18 4500PF	SM18 10200H	SM18 10200H
DATE PREPARED	05/31/11		05/26/11	05/26/11
DATE ANALYZED	06/01/11		06/02/11	06/02/11
DETECTION LIMIT	0.002	0.001	0.1	0.1
DUPLICATE				
SAMPLE ID	KETCHUM-1M	KETCHUM-1M	KETCHUM-1M	KETCHUM-1M
ORIGINAL	0.135	0.022	64	9.6
DUPLICATE	0.137	0.023	70	11
RPD	2.04%	3.73%	8.76%	12.07%
SPIKE SAMPLE				
SAMPLE ID	KETCHUM-1M	KETCHUM-1M		
ORIGINAL	0.135	0.022		
SPIKED SAMPLE	0.186	0.042		
SPIKE ADDED	0.050	0.020		
% RECOVERY	102.24%	96.95%	NA	NA
QC CHECK				
FOUND	0.091	0.032		
TRUE	0.090	0.033		
% RECOVERY	101.14%	98.06%	NA	NA
BLANK	<0.002	<0.001	NA	NA

RPD = RELATIVE PERCENT DIFFERENCE.

NA = NOT APPLICABLE OR NOT AVAILABLE.

NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.

OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

**SUBMITTED BY:**

Steven Lazoff  
 Laboratory Director

June 2012  
SN000551

**AQUATIC RESEARCH INCORPORATED****LABORATORY & CONSULTING SERVICES**

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<b>CASE FILE NUMBER:</b>	<b>SNO005-54</b>	<b>PAGE 1</b>
<b>REPORT DATE:</b>	<b>06/18/11</b>	
<b>DATE SAMPLED:</b>	<b>06/07/11</b>	<b>DATE RECEIVED: 06/08/11</b>
<b>FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER</b>		
<b>SAMPLES FROM SNOHOMISH COUNTY SWM</b>		

**CASE NARRATIVE**

Six water samples were received by the laboratory in good condition and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on subsequent pages.

**SAMPLE DATA**

SAMPLE ID	TOTAL-P (mg/l)	SRP (mg/l)	AMMONIA (mg/l)	N03+N02 (mg/l)	TKN (mg/l)	CHLOR_a (ug/l)	PHAEO_a (ug/l)
KETCHUM 1M	0.172	0.008	<0.010	<0.010	2.04	174	7.3
KETCHUM 2M	0.120	0.025					
KETCHUM 2M DUPE	0.122	0.025					
KETCHUM 4M	1.16	0.910					
KETCHUM 5M	2.45	2.01	1.61	<0.010	2.01		
KETCHUM INLET	0.458	0.424					

TRUE COLOR	
SAMPLE ID	(pcu)
KETCHUM 1M	45

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<b>CASE FILE NUMBER:</b>	<b>SNO005-54</b>	<b>PAGE 2</b>
<b>REPORT DATE:</b>	<b>06/18/11</b>	
<b>DATE SAMPLED:</b>	<b>06/07/11</b>	<b>DATE RECEIVED: 06/08/11</b>
<b>FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER</b>		
<b>SAMPLES FROM SNOHOMISH COUNTY SWM</b>		

**QA/QC DATA**

QC PARAMETER	TOTAL-P (mg/l)	SRP (mg/l)	AMMONIA (mg/l)	N03+N02 (mg/l)	TKN (mg/l)	CHLOR_a (ug/l)	PHAE0_a (ug/l)
METHOD	SM18 4500PF	SM18 4500PF	SM184500NH3H	SM184500N03F	EPA 351.1	SM18 10200H	SM18 10200H
DATE PREPARED	06/10/11					06/08/11	06/08/11
DATE ANALYZED	06/13/11	06/08/11	06/08/11	06/08/11	06/15/11	06/16/11	06/16/11
DETECTION LIMIT	0.002	0.001	0.010	0.010	0.200	0.1	0.1
DUPLICATE							
SAMPLE ID	BATCH	KETCHUM 1M	BATCH	BATCH	KETCHUM 5M	KETCHUM 1M	KETCHUM 1M
ORIGINAL	0.085	0.008	<0.010	0.124	2.01	174	7.3
DUPLICATE	0.086	0.008	<0.010	0.125	2.07	172	6.3
RPD	1.26%	1.10%	NC	0.44%	2.72%	0.77%	14.78%
SPIKE SAMPLE							
SAMPLE ID	BATCH	KETCHUM 1M	BATCH	BATCH	KETCHUM 5M		
ORIGINAL	0.085	0.008	<0.010	0.124	2.01		
SPIKED SAMPLE	0.136	0.027	0.193	0.324	4.11		
SPIKE ADDED	0.050	0.020	0.200	0.200	2.00		
% RECOVERY	102.92%	95.30%	96.28%	99.78%	104.78%	NA	NA
QC CHECK							
FOUND	0.091	0.033	0.311	0.424	5.86		
TRUE	0.090	0.033	0.324	0.408	5.79		
% RECOVERY	100.98%	100.22%	96.11%	103.93%	101.24%	NA	NA
BLANK	<0.002	<0.001	<0.010	<0.010	<0.200	NA	NA

RPD = RELATIVE PERCENT DIFFERENCE.

NA = NOT APPLICABLE OR NOT AVAILABLE.

NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.

OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.



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3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

<b>CASE FILE NUMBER:</b>	<b>SNO005-54</b>	<b>PAGE 3</b>
<b>REPORT DATE:</b>	<b>06/18/11</b>	
<b>DATE SAMPLED:</b>	<b>06/07/11</b>	<b>DATE RECEIVED: 06/08/11</b>
<b>FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER</b>		
<b>SAMPLES FROM SNOHOMISH COUNTY SWM</b>		

**QA/QC DATA**

QC PARAMETER	TRUE COLOR (pcu)
METHOD	EPA 110.2
DATE PREPARED	
DATE ANALYZED	06/09/11
DETECTION LIMIT	5
DUPLICATE	
SAMPLE ID	
ORIGINAL	
DUPLICATE	
RPD	NA
SPIKE SAMPLE	
SAMPLE ID	
ORIGINAL	
SPIKED SAMPLE	
SPIKE ADDED	
% RECOVERY	NA
QC CHECK	
FOUND	
TRUE	
% RECOVERY	NA
BLANK	<5

RPD = RELATIVE PERCENT DIFFERENCE.

NA = NOT APPLICABLE OR NOT AVAILABLE.

NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.

OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

**SUBMITTED BY:**

Steven Lazoff  
Laboratory Director



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SHEET 1 OF 1

PROJECT ID: Ketchum  
CASE FILE NO.:  
DATA RECORDED BY:

### PARAMETERS

[illegible]

Relinquished By	Date/Time	Received By	Date/Time
Printed Name <i>Gene Williams</i>	<i>6/8/11 8:25</i>	<i>S. HILLSON</i>	<i>6/8/11</i>
Signature <i>[Signature]</i>		<i>[Signature]</i>	<i>0825</i>
Affiliation <i>Snohomish County - SWM</i>		<i>AMS</i>	

Relinquished By	Date/Time	Received By	Date/Time
Printed Name			
Signature			
Affiliation			

Miscellaneous Notes (Hazardous Materials, Quick turn-around time, etc.):

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<b>CASE FILE NUMBER:</b>	<b>SNO005-61</b>	<b>PAGE 1</b>
<b>REPORT DATE:</b>	<b>07/07/11</b>	
<b>DATE SAMPLED:</b>	<b>06/22/11</b>	<b>DATE RECEIVED: 06/22/11</b>
<b>FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER</b>		
<b>SAMPLES FROM SNOHOMISH COUNTY SWM</b>		

**CASE NARRATIVE**

Six water samples were received by the laboratory in good condition and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on subsequent pages.

**SAMPLE DATA**

SAMPLE ID	TOTAL-P (mg/l)	SRP (mg/l)	AMMONIA (mg/l)	N03+N02 (mg/l)	TKN (mg/l)	CHLOR_a (ug/l)	PHAEO_a (ug/l)
KETCHUM 1M	0.119	0.004	0.123	0.015	1.14	47	9.5
KETCHUM 2M	0.157	0.076					
KETCHUM 2M DUPE	0.157	0.078					
KETCHUM 4M	0.972	0.766					
KETCHUM 5M	2.82	2.18	2.12	<0.010	2.25		
KETCHUM INLET	0.475	0.371					

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<b>CASE FILE NUMBER:</b>	<b>SNO005-61</b>	<b>PAGE 2</b>
<b>REPORT DATE:</b>	<b>07/07/11</b>	
<b>DATE SAMPLED:</b>	<b>06/22/11</b>	<b>DATE RECEIVED: 06/22/11</b>
<b>FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER</b>		
<b>SAMPLES FROM SNOHOMISH COUNTY SWM</b>		

**QA/QC DATA**

QC PARAMETER	TOTAL-P (mg/l)	SRP (mg/l)	AMMONIA (mg/l)	N03+N02 (mg/l)	TKN (mg/l)	CHLOR_a (ug/l)	PHAE0_a (ug/l)
METHOD	SM18 4500PF	SM18 4500PF	SM184500NH3H	SM184500N03F	EPA 351.1	SM18 10200H	SM18 10200H
DATE PREPARED	06/24/11					06/23/11	06/23/11
DATE ANALYZED	06/27/11	06/23/11	06/24/11	06/24/11	07/06/11	06/30/11	06/30/11
DETECTION LIMIT	0.002	0.001	0.010	0.010	0.200	0.1	0.1
DUPLICATE							
SAMPLE ID	BATCH	BATCH	BATCH	BATCH	BATCH	BATCH	BATCH
ORIGINAL	0.046	0.018	<0.010	<0.010	0.371	44	7.8
DUPLICATE	0.045	0.019	<0.010	<0.010	0.386	45	9.0
RPD	1.29%	5.25%	NC	NC	4.01%	2.41%	14.01%
SPIKE SAMPLE							
SAMPLE ID	BATCH	BATCH	BATCH	BATCH	BATCH		
ORIGINAL	0.046	0.018	<0.010	<0.010	0.371		
SPIKED SAMPLE	0.097	0.038	0.203	0.217	2.40		
SPIKE ADDED	0.050	0.020	0.200	0.200	2.00		
% RECOVERY	103.84%	100.38%	101.59%	108.54%	101.49%	NA	NA
QC CHECK							
FOUND	0.090	0.033	0.340	0.414	5.93		
TRUE	0.090	0.033	0.324	0.408	5.79		
% RECOVERY	100.30%	99.38%	104.98%	101.38%	102.50%	NA	NA
BLANK	<0.002	<0.001	<0.010	<0.010	<0.200	NA	NA

RPD = RELATIVE PERCENT DIFFERENCE.

NA = NOT APPLICABLE OR NOT AVAILABLE.

NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.

OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Steven Lazoff  
Laboratory Director

3927 Aurora Avenue N, Seattle, WA 98103  
P 206.632.2715 | F 206.632.2417

540005 June 2012

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SHEET 1 OF 1

SAMPLING DATE: June 22, 2011

SAMPLERS: G. Williams, M. Pott

CASE FILE NO.:

DATA RECORDED BY: \_\_\_\_\_

## SAMPLE INFORMATION

Relinquished By	Date/Time	Received By	Date/Time
Printed Name <i>Gare Williams</i>	<i>6/22/11 3:45 pm</i>	<i>Jesse Billingshan</i>	<i>6/22/11 3:45 pm</i>
Signature <i>Gare Williams</i>		<i>[Signature]</i>	
Affiliation <i>Snohomish County SWM</i>			

Relinquished By	Date/Time	Received By	Date/Time
Printed Name <i>Jesse Billingshan</i>	<i>6/22/11 4:25 pm</i>	<i>S. Hillgren</i>	<i>6/22/11</i>
Signature <i>[Signature]</i>		<i>[Signature]</i>	
Affiliation		<i>AND</i>	<i>1625</i>

Miscellaneous Notes (Hazardous Materials, Quick turn-around time, etc.):

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3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

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<b>CASE FILE NUMBER:</b>	<b>SNO005-64</b>	<b>PAGE 1</b>
<b>REPORT DATE:</b>	<b>08/01/11</b>	
<b>DATE SAMPLED:</b>	<b>07/13/11</b>	<b>DATE RECEIVED: 07/14/11</b>
<b>FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER</b>		
<b>SAMPLES FROM SNOHOMISH COUNTY SWM</b>		

**CASE NARRATIVE**

Seven water samples were received by the laboratory in good condition and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on subsequent pages.

**SAMPLE DATA**

SAMPLE ID	TOTAL-P (mg/l)	SRP (mg/l)	AMMONIA (mg/l)	N03+N02 (mg/l)	TKN (mg/l)	CHLOR_a (ug/l)	PHAEO_a (ug/l)
KETCHUM 1M	0.078	0.002	0.199	0.020	1.26	18	<0.1
KETCHUM 1M DUPE						17	0.5
KETCHUM 2M	0.086	0.002					
KETCHUM 4M	1.09	0.973					
KETCHUM 5M	1.97	1.43	1.31	0.012	2.07		
KETCHUM 5M DUPE	1.84	1.66	1.29	0.012	2.21		
KETCHUM INLET	0.503	0.407					

SAMPLE ID	TRUE COLOR (pcu)
KETCHUM 1M	45

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<b>CASE FILE NUMBER:</b>	<b>SNO005-64</b>	<b>PAGE 2</b>
<b>REPORT DATE:</b>	<b>08/01/11</b>	
<b>DATE SAMPLED:</b>	<b>07/13/11</b>	<b>DATE RECEIVED: 07/14/11</b>
<b>FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER</b>		
<b>SAMPLES FROM SNOHOMISH COUNTY SWM</b>		

**QA/QC DATA**

QC PARAMETER	TOTAL-P (mg/l)	SRP (mg/l)	AMMONIA (mg/l)	N03+N02 (mg/l)	TKN (mg/l)	CHLOR_a (ug/l)	PHAE0_a (ug/l)
METHOD	SM18 4500PF	SM18 4500PF	SM184500NH3H	SM184500N03F	EPA 351.1	SM18 10200H	SM18 10200H
DATE PREPARED	07/22/11					07/15/11	07/15/11
DATE ANALYZED	07/25/11	07/15/11	07/14/11	07/14/11	07/14/11	07/27/11	07/27/11
DETECTION LIMIT	0.002	0.001	0.010	0.010	0.200	0.1	0.1
DUPLICATE							
SAMPLE ID	BATCH	BATCH	BATCH	BATCH	BATCH	BATCH	BATCH
ORIGINAL	0.043	0.043	0.011	0.208	0.239	329	219
DUPLICATE	0.042	0.043	0.011	0.203	0.218	383	203
RPD	1.39%	0.65%	7.99%	2.16%	9.33%	15.00%	7.59%
SPIKE SAMPLE							
SAMPLE ID	BATCH	BATCH	BATCH	BATCH	BATCH		
ORIGINAL	0.043	0.043	0.011	0.208	0.239		
SPIKED SAMPLE	0.094	0.063	0.213	0.403	2.23		
SPIKE ADDED	0.050	0.020	0.200	0.200	2.00		
% RECOVERY	101.92%	100.07%	101.00%	97.84%	99.66%	NA	NA
QC CHECK							
FOUND	0.092	0.033	0.322	0.400	5.57		
TRUE	0.090	0.033	0.324	0.408	5.79		
% RECOVERY	102.77%	100.13%	99.36%	97.99%	96.24%	NA	NA
BLANK	<0.002	<0.001	<0.010	<0.010	<0.200	NA	NA

RPD = RELATIVE PERCENT DIFFERENCE.

NA = NOT APPLICABLE OR NOT AVAILABLE.

NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.

OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

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<b>CASE FILE NUMBER:</b>	<b>SNO005-64</b>	<b>PAGE 3</b>
<b>REPORT DATE:</b>	<b>08/01/11</b>	
<b>DATE SAMPLED:</b>	<b>07/13/11</b>	<b>DATE RECEIVED: 07/14/11</b>
<b>FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER</b>		
<b>SAMPLES FROM SNOHOMISH COUNTY SWM</b>		

**QA/QC DATA**

QC PARAMETER	TRUE COLOR (pcu)
METHOD	EPA 110.2
DATE PREPARED	
DATE ANALYZED	07/14/11
DETECTION LIMIT	5
DUPLICATE	
SAMPLE ID	
ORIGINAL	
DUPLICATE	
RPD	NA
SPIKE SAMPLE	
SAMPLE ID	
ORIGINAL	
SPIKED SAMPLE	
SPIKE ADDED	
% RECOVERY	NA
QC CHECK	
FOUND	
TRUE	
% RECOVERY	NA
BLANK	<5

RPD = RELATIVE PERCENT DIFFERENCE.

NA = NOT APPLICABLE OR NOT AVAILABLE.

NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.

OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

**SUBMITTED BY:**

Steven Lazoff  
Laboratory Director



**P 206.632.2715 | F 206.632.2417**

SHEET 1 OF 1

SAMPLERS: M. Brighdaff; M. Pott

DATA RECORDED BY:

## PARAMETERS

Relinquished By	Date/Time	Received By	Date/Time
Printed Name <i>Mona Williams</i>	<i>7/13/11 11:50</i>	<i>Nina Williams</i>	<i>7/13/11 4:50</i>
Signature <i>[Signature]</i>		<i>Nina Williams</i>	
Affiliation <i>Snohomish County - SWM</i>			

Relinquished By	Date/Time	Received By	Date/Time
Printed Name <i>Nina Williams</i>	<i>7/14/11 8:34</i>	<i>Olga Andarayan</i>	<i>7/14/11 8:34</i>
Signature <i>Nina A. Williams</i>		<i>[Signature]</i>	
Affiliation		<i>ART</i>	

3927 Aurora Ave. N | Seattle, WA 98103 | 206.642.5715

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3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

<b>CASE FILE NUMBER:</b>	<b>SNO005-69</b>	<b>PAGE 1</b>
<b>REPORT DATE:</b>	<b>08/10/11</b>	
<b>DATE SAMPLED:</b>	<b>07/27/11</b>	<b>DATE RECEIVED: 07/27/11</b>
<b>FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER</b>		
<b>SAMPLES FROM SNOHOMISH COUNTY SWM</b>		

**CASE NARRATIVE**

Five water samples were received by the laboratory in good condition and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on subsequent pages.

**SAMPLE DATA**

SAMPLE ID	TOTAL-P (mg/l)	SRP (mg/l)	AMMONIA (mg/l)	N03+N02 (mg/l)	TKN (mg/l)	CHLOR_a (ug/l)	PHAEO_a (ug/l)
KETCHUM 1M	0.089	0.005	<0.010	0.022	0.783	76	10
KETCHUM 2M	0.127	0.008					
KETCHUM 4M	1.31	1.10					
KETCHUM 4M DUPE	1.33	1.13					
KETCHUM 5M	3.61	3.12	4.74	0.013	5.24		

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<b>CASE FILE NUMBER:</b>	<b>SNO005-69</b>	<b>PAGE 2</b>
<b>REPORT DATE:</b>	<b>08/10/11</b>	
<b>DATE SAMPLED:</b>	<b>07/27/11</b>	<b>DATE RECEIVED: 07/27/11</b>
<b>FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER</b>		
<b>SAMPLES FROM SNOHOMISH COUNTY SWM</b>		

**QA/QC DATA**

QC PARAMETER	TOTAL-P (mg/l)	SRP (mg/l)	AMMONIA (mg/l)	N03+N02 (mg/l)	TKN (mg/l)	CHLOR_a (ug/l)	PHAE0_a (ug/l)
METHOD	SM18 4500PF	SM18 4500PF	SM184500NH3H	SM184500N03F	EPA 351.1	SM18 10200H	SM18 10200H
DATE PREPARED	07/28/11					07/28/11	07/28/11
DATE ANALYZED	07/29/11	07/29/11	07/29/11	07/29/11	08/05/11	08/10/11	08/10/11
DETECTION LIMIT	0.002	0.001	0.010	0.010	0.200	0.1	0.1
DUPLICATE							
SAMPLE ID	BATCH	BATCH	BATCH	BATCH	KETCHUM 5M	KETCHUM 1M	KETCHUM 1M
ORIGINAL	0.044	0.004	0.118	0.035	5.24	76	10
DUPLICATE	0.046	0.004	0.122	0.039	5.02	70	9.7
RPD	4.29%	1.79%	3.32%	11.15%	4.25%	8.06%	4.85%
SPIKE SAMPLE							
SAMPLE ID	BATCH	BATCH	BATCH	BATCH	KETCHUM 5M		
ORIGINAL	0.044	0.004	0.118	0.035	5.24		
SPIKED SAMPLE	0.094	0.024	0.316	0.229	7.23		
SPIKE ADDED	0.050	0.020	0.200	0.200	2.00		
% RECOVERY	100.34%	102.04%	99.08%	97.09%	99.64%	NA	NA
QC CHECK							
FOUND	0.090	0.033	0.322	0.415	5.88		
TRUE	0.090	0.033	0.324	0.408	5.79		
% RECOVERY	99.86%	100.28%	99.47%	101.67%	101.49%	NA	NA
BLANK	<0.002	<0.001	<0.010	<0.010	<0.200	NA	NA

RPD = RELATIVE PERCENT DIFFERENCE.

NA = NOT APPLICABLE OR NOT AVAILABLE.

NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.

OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Steven Lazoff  
Laboratory Director



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SHEET 1 OF 1

**CASE FILE NO.:**

DATA RECORDED BY:



SAMPLING DATE: July 27, 2011

SAMPLERS: G. Williams, M. Buzdoff

## PARAMETERS

[illegible]

Printed Name	Relinquished By <i>Gene Williams</i>	Date/Time <i>7/27/11 3:30 pm</i>	Received By <i>Jesse Billigh</i>	Date/Time <i>7/27/11 3:30 pm</i>
Signature	<i>Gene Williams</i>		<i>[Signature]</i>	
Affiliation	Snohomish County - SWM		<i>SWM</i>	

Printed Name	Relinquished By Jesse Brittingham	Date/Time 7/27/11 4:45	Received By S. HILSON	Date/Time 7/27/11 1645
Signature				
Affiliation	SWA		SWA	

**Miscellaneous Notes (Hazardous Materials, Quick turn-around time, etc.):**

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PHONE: (206) 632-2715 FAX: (206) 632-2417

<b>CASE FILE NUMBER:</b>	<b>SNO005-71</b>	<b>PAGE 1</b>
<b>REPORT DATE:</b>	<b>08/23/11</b>	
<b>DATE SAMPLED:</b>	<b>08/10/11</b>	<b>DATE RECEIVED: 08/11/11</b>
<b>FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER</b>		
<b>SAMPLES FROM SNOHOMISH COUNTY SWM</b>		

**CASE NARRATIVE**

Six samples were delivered to the laboratory in good condition. The samples were analyzed according to the chain of custody. Samples for True Color were filtered through a 0.45 um nylon filter before analysis. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on subsequent pages.

**SAMPLE DATA**

SAMPLE ID	TOTAL-P (mg/l)	SRP (mg/l)	AMMONIA (mg/l)	N03+N02 (mg/l)	TKN (mg/l)	CHLOR_a (ug/l)	PHAEO_a (ug/l)
KETCHUM-1M	0.072	0.005	<0.010	<0.010	0.920	46	3.8
KETCHUM-1M DUPE						48	4.1
KETCHUM-2M	0.128	0.011					
KETCHUM-4M	1.77	1.38					
KETCHUM-4M DUPE	1.88	1.51					
KETCHUM-5M	3.16	2.47	3.43	0.011	3.59		

TRUE COLOR	
SAMPLE ID	(pcu)
KETCHUM-1M	40

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PHONE: (206) 632-2715 FAX: (206) 632-2417

<b>CASE FILE NUMBER:</b>	<b>SNO005-71</b>	<b>PAGE 2</b>
<b>REPORT DATE:</b>	<b>08/23/11</b>	
<b>DATE SAMPLED:</b>	<b>08/10/11</b>	<b>DATE RECEIVED: 08/11/11</b>
<b>FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER</b>		
<b>SAMPLES FROM SNOHOMISH COUNTY SWM</b>		

**QA/QC DATA**

QC PARAMETER	TOTAL-P (mg/l)	SRP (mg/l)	AMMONIA (mg/l)	N03+N02 (mg/l)	TKN (mg/l)	CHLOR_a (ug/l)	PHAE0_a (ug/l)
METHOD	SM18 4500PF	SM18 4500PF	SM184500NH3H	SM184500N03F	EPA 351.1	SM18 10200H	SM18 10200H
DATE PREPARED	08/18/11					08/12/11	08/12/11
DATE ANALYZED	08/22/11	08/12/11	08/12/11	08/12/11	08/18/11	08/23/11	08/23/11
DETECTION LIMIT	0.002	0.001	0.010	0.010	0.200	0.1	0.1
DUPLICATE							
SAMPLE ID	BATCH	BATCH	BATCH	BATCH	BATCH	BATCH	BATCH
ORIGINAL	0.004	0.002	<0.010	<0.010	0.772	11	6.7
DUPLICATE	0.004	0.002	<0.010	<0.010	0.753	12	8.1
RPD	4.97%	0.20%	NC	NC	2.56%	4.65%	18.05%
SPIKE SAMPLE							
SAMPLE ID	BATCH	BATCH	BATCH	BATCH	BATCH		
ORIGINAL	0.004	0.002	<0.010	<0.010	0.772		
SPIKED SAMPLE	0.053	0.022	0.206	0.209	2.86		
SPIKE ADDED	0.050	0.020	0.200	0.200	2.00		
% RECOVERY	99.23%	97.61%	103.00%	104.49%	104.51%	NA	NA
QC CHECK							
FOUND	0.091	0.033	0.327	0.415	5.79		
TRUE	0.090	0.033	0.324	0.408	5.79		
% RECOVERY	100.72%	99.43%	101.02%	101.76%	99.97%	NA	NA
BLANK	<0.002	<0.001	<0.010	<0.010	<0.200	NA	NA

RPD = RELATIVE PERCENT DIFFERENCE.

NA = NOT APPLICABLE OR NOT AVAILABLE.

NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.

OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

**AQUATIC RESEARCH INCORPORATED****LABORATORY & CONSULTING SERVICES**

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

<b>CASE FILE NUMBER:</b>	<b>SNO005-71</b>	<b>PAGE 3</b>
<b>REPORT DATE:</b>	<b>08/23/11</b>	
<b>DATE SAMPLED:</b>	<b>08/10/11</b>	<b>DATE RECEIVED: 08/11/11</b>
<b>FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER</b>		
<b>SAMPLES FROM SNOHOMISH COUNTY SWM</b>		

**QA/QC DATA**

QC PARAMETER	TRUE COLOR (pcu)
METHOD	EPA 110.2
DATE PREPARED	
DATE ANALYZED	08/12/11
DETECTION LIMIT	5
DUPLICATE	
SAMPLE ID	
ORIGINAL	
DUPLICATE	
RPD	NA
SPIKE SAMPLE	
SAMPLE ID	
ORIGINAL	
SPIKED SAMPLE	
SPIKE ADDED	
% RECOVERY	NA
QC CHECK	
FOUND	
TRUE	
% RECOVERY	NA
BLANK	<5

RPD = RELATIVE PERCENT DIFFERENCE.

NA = NOT APPLICABLE OR NOT AVAILABLE.

NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.

OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Steven Lazoff  
Laboratory Director

P 206.632.2715 | F 206.632.2417

~~SNOWHOMISTIA CO. SWM~~  
~~CHAIN-OF-CUSTODY RECORD~~

SAMPLING DATE: August 10, 2011

SAMPLERS: G. Williams, K. Trepstra

**SHEET / OF**

PROJECT ID: Ket drum

**CASE FILE NO.:**

DATA RECORDED BY:

## PARAMETERS

[illegible]

Relinquished By	Date/Time	Received By	Date/Time
Printed Name <i>Gene Williams</i>	<i>8/11/11 7:00</i>	<i>Nina Williams</i>	<i>8/11/11 7:00</i>
Signature <i>Gene Williams</i>		<i>(X) Nina Williams</i>	
Affiliation <i>and Co LLC</i>			

Printed Name	Relinquished By	Date/Time	Received By	Date/Time
Nina Williams	Nina Williams	8/11/11 9:20	S. HILSON	8/11/11
Signature	(S) Nina Williams			0920
Affiliation			ARI	

Miscellaneous Notes (Hazardous Materials, Quick turn-around time, etc.):



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3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

<b>CASE FILE NUMBER:</b>	<b>SNO005-79</b>	<b>PAGE 1</b>
<b>REPORT DATE:</b>	<b>09/07/11</b>	
<b>DATE SAMPLED:</b>	<b>08/24/11</b>	<b>DATE RECEIVED: 08/24/11</b>
<b>FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER</b>		
<b>SAMPLES FROM SNOHOMISH COUNTY SWM</b>		

**CASE NARRATIVE**

Five water samples were received by the laboratory in good condition and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on subsequent pages.

**SAMPLE DATA**

SAMPLE ID	TOTAL-P (mg/l)	SRP (mg/l)	AMMONIA (mg/l)	N03+N02 (mg/l)	TKN (mg/l)	CHLOR_a (ug/l)	PHAEO_a (ug/l)
KETCHUM-1M	0.075	0.004	<0.010	<0.010	0.752	43	1.8
KETCHUM-2M	0.328	0.008					
KETCHUM-4M	2.39	1.83					
KETCHUM-5M	3.69	2.49	4.89	0.011	6.08		
KETCHUM-5M DUP	3.55	2.42	4.44	0.012	6.04		

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<b>CASE FILE NUMBER:</b>	<b>SNO005-79</b>	<b>PAGE 2</b>
<b>REPORT DATE:</b>	<b>09/07/11</b>	
<b>DATE SAMPLED:</b>	<b>08/24/11</b>	<b>DATE RECEIVED: 08/24/11</b>
<b>FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER</b>		
<b>SAMPLES FROM SNOHOMISH COUNTY SWM</b>		

**QA/QC DATA**

QC PARAMETER	TOTAL-P (mg/l)	SRP (mg/l)	AMMONIA (mg/l)	N03+N02 (mg/l)	TKN (mg/l)	CHLOR_a (ug/l)	PHAE0_a (ug/l)
METHOD	SM18 4500PF	SM18 4500PF	SM184500NH3H	SM184500N03F	EPA 351.1	SM18 10200H	SM18 10200H
DATE PREPARED	08/31/11					08/25/11	08/25/11
DATE ANALYZED	09/06/11	08/25/11	08/25/11	08/25/11	09/02/11	08/31/11	08/31/11
DETECTION LIMIT	0.002	0.001	0.010	0.010	0.200	0.1	0.1
DUPLICATE							
SAMPLE ID	KETCHUM-1M	BATCH	BATCH	BATCH	BATCH	BATCH	BATCH
ORIGINAL	0.075	0.003	<0.010	<0.010	0.761	23816	4293
DUPLICATE	0.076	0.002	<0.010	<0.010	0.783	25525	4454
RPD	2.06%	9.36%	NC	NC	2.89%	6.93%	3.66%
SPIKE SAMPLE							
SAMPLE ID	KETCHUM-1M	BATCH	BATCH	BATCH	BATCH		
ORIGINAL	0.075	0.003	<0.010	<0.010	0.761		
SPIKED SAMPLE	0.123	0.024	0.208	0.194	2.71		
SPIKE ADDED	0.050	0.020	0.200	0.200	2.00		
% RECOVERY	96.00%	107.75%	104.12%	96.86%	97.58%	NA	NA
QC CHECK							
FOUND	0.090	0.033	0.328	0.418	6.05		
TRUE	0.090	0.033	0.324	0.408	5.79		
% RECOVERY	100.44%	99.86%	101.09%	102.46%	104.43%	NA	NA
BLANK	<0.002	<0.001	<0.010	<0.010	<0.200	NA	NA

RPD = RELATIVE PERCENT DIFFERENCE.

NA = NOT APPLICABLE OR NOT AVAILABLE.

NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.

OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Steven Lazoff  
Laboratory Director



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SHEET 1 OF 1

**P 206.632.2715 | F 206.632.2417**

**PROJECT ID:** Ketchum

**CASE FILE NO.:**

DATA RECORDED BY:

## SAMPLE INFORMATION

[illegible]

Relinquished By	Date/Time	Received By	Date/Time
Printed Name <i>Jose Dillman</i>	<i>8/24/11 16:40</i>	<i>S. H. Wilson</i>	<i>8/24/11</i>
Signature <i>[Signature]</i>		<i>[Signature]</i>	<i>16:40</i>
Affiliation <i>Stromboli County - SWM</i>		<i>LAW</i>	

Printed Name	Relinquished By	Date/Time	Received By	Date/Time
Signature				
Affiliation				

Miscellaneous Notes (Hazardous Materials, Quick turn-around time, etc.):

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3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

<b>CASE FILE NUMBER:</b>	<b>SNO005-83A</b>	<b>PAGE 1</b>
<b>REPORT DATE:</b>	<b>10/12/11</b>	
<b>DATE SAMPLED:</b>	<b>09/13/11</b>	<b>DATE RECEIVED: 09/14/11</b>
<b>FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER</b>		
<b>SAMPLES FROM SNOHOMISH COUNTY SWM</b>		

**CASE NARRATIVE**

Four water samples were received by the laboratory in good condition and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on subsequent pages.

**SAMPLE DATA**

SAMPLE ID	TOTAL-P (mg/l)	SRP (mg/l)	AMMONIA (mg/l)	N03+N02 (mg/l)	TKN (mg/l)	CHLOR_a (ug/l)	PHAEO_a (ug/l)
KETCHUM - 1M	0.081	0.010	<0.010	<0.010	1.89	23	1.8
KETCHUM - 2M	0.424	0.051					
KETCHUM - 4	3.31	2.55					
KETCHUM - 5M	3.48	3.23	4.79	0.014	6.65		

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<b>CASE FILE NUMBER:</b>	<b>SNO005-83A</b>	<b>PAGE 2</b>
<b>REPORT DATE:</b>	<b>10/12/11</b>	
<b>DATE SAMPLED:</b>	<b>09/13/11</b>	<b>DATE RECEIVED: 09/14/11</b>
<b>FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER</b>		
<b>SAMPLES FROM SNOHOMISH COUNTY SWM</b>		

**QA/QC DATA**

QC PARAMETER	TOTAL-P (mg/l)	SRP (mg/l)	AMMONIA (mg/l)	N03+N02 (mg/l)	TKN (mg/l)	CHLOR_a (ug/l)	PHAE0_a (ug/l)
METHOD	SM18 4500PF	SM18 4500PF	SM184500NH3H	SM184500N03F	EPA 351.1	SM18 10200H	SM18 10200H
DATE PREPARED	09/16/11					09/14/11	09/14/11
DATE ANALYZED	09/19/11	09/15/11	09/15/11	09/15/11	10/06/11	09/30/11	09/30/11
DETECTION LIMIT	0.002	0.001	0.010	0.010	0.200	0.1	0.1
DUPLICATE							
SAMPLE ID	BATCH	BATCH	BATCH	BATCH	BATCH	KETCHUM	KETCHUM
ORIGINAL	0.022	0.039	0.224	0.068	1.28	23	1.8
DUPLICATE	0.023	0.039	0.225	0.062	1.25	28	1.7
RPD	3.38%	1.23%	0.23%	9.35%	2.35%	16.84%	9.23%
SPIKE SAMPLE							
SAMPLE ID	BATCH	BATCH	BATCH	BATCH	BATCH		
ORIGINAL	0.022	0.039	0.224	0.068	1.28		
SPIKED SAMPLE	0.073	0.061	0.433	0.269	3.49		
SPIKE ADDED	0.050	0.020	0.200	0.200	2.00		
% RECOVERY	103.07%	107.13%	104.35%	100.91%	110.40%	NA	NA
QC CHECK							
FOUND	0.090	0.033	0.322	0.413	5.92		
TRUE	0.090	0.033	0.324	0.408	5.79		
% RECOVERY	100.26%	101.31%	99.25%	101.35%	102.33%	NA	NA
BLANK	<0.002	<0.001	<0.010	<0.010	<0.200	NA	NA

RPD = RELATIVE PERCENT DIFFERENCE.

NA = NOT APPLICABLE OR NOT AVAILABLE.

NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.

OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Damien Gadowski  
Project Manager

3927 Aurora Avenue N, Seattle, WA 98103  
P 206.632.2715 | F 206.632.2417

SND 005-83

June 2012

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SHEET 1 OF 1

SAMPLING DATE: ~~9/11/11~~ 9/13/11

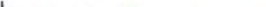
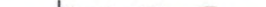
SAMPLERS: G. Williams. M. Burroughs



CASE FILE NO.:

DATA RECORDED BY: \_\_\_\_\_

## PARAMETERS

[illegible]

Printed Name	Relinquished By Nancy Burdett	Date/Time 9/14/12:25	Received By	Date/Time
Signature				
Affiliation	Snohomish County - SWM			

Printed Name	Relinquished By Jesse Billingham	Date/Time 9/14/11 15:45	Received By Karinka Sasa	Date/Time 9/14/11 15:45
Signature				
Affiliation	San Jo Sun		Aquatic Research	

Miscellaneous Notes (Hazardous Materials, Quick turn-around time, etc.):

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3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

<b>CASE FILE NUMBER:</b>	<b>SNO005-88</b>	<b>PAGE 1</b>
<b>REPORT DATE:</b>	<b>10/11/11</b>	
<b>DATE SAMPLED:</b>	<b>09/28/11</b>	<b>DATE RECEIVED: 09/28/11</b>
<b>FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER</b>		
<b>SAMPLES FROM SNOHOMISH COUNTY SWM</b>		

**CASE NARRATIVE**

Five water samples were received by the laboratory in good condition and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on subsequent pages.

**SAMPLE DATA**

SAMPLE ID	TOTAL-P (mg/l)	SRP (mg/l)	AMMONIA (mg/l)	N03+N02 (mg/l)	TKN (mg/l)	CHLOR_a (ug/l)	PHAEO_a (ug/l)
KETCHUM - 1M	0.222	0.114	0.011	<0.010	1.11	54	5.6
KETCHUM - 2M	0.251	0.118					
KETCHUM - 2M DUP	0.219	0.118					
KETCHUM - 4M	1.70	1.56					
KETCHUM - 5M	3.61	3.12	6.29	0.012	8.93		



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<b>CASE FILE NUMBER:</b>	<b>SNO005-88</b>	<b>PAGE 2</b>
<b>REPORT DATE:</b>	<b>10/11/11</b>	
<b>DATE SAMPLED:</b>	<b>09/28/11</b>	<b>DATE RECEIVED: 09/28/11</b>
<b>FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER</b>		
<b>SAMPLES FROM SNOHOMISH COUNTY SWM</b>		

**QA/QC DATA**

QC PARAMETER	TOTAL-P (mg/l)	SRP (mg/l)	AMMONIA (mg/l)	N03+N02 (mg/l)	TKN (mg/l)	CHLOR_a (ug/l)	PHAE0_a (ug/l)
METHOD	SM18 4500PF	SM18 4500PF	SM184500NH3H	SM184500N03F	EPA 351.1	SM18 10200H	SM18 10200H
DATE PREPARED	09/30/11					09/29/11	09/29/11
DATE ANALYZED	10/03/11	09/30/11	09/29/11	09/29/11	10/06/11	10/11/11	10/11/11
DETECTION LIMIT	0.002	0.001	0.010	0.010	0.200	0.1	0.1
DUPLICATE							
SAMPLE ID	BATCH	BATCH	BATCH	BATCH	BATCH	BATCH	BATCH
ORIGINAL	0.045	0.009	0.165	0.015	1.28	3.2	<0.1
DUPLICATE	0.045	0.009	0.167	0.015	1.25	2.9	<0.1
RPD	0.00%	3.22%	1.12%	3.31%	2.35%	8.70%	NC
SPIKE SAMPLE							
SAMPLE ID	BATCH	BATCH	BATCH	BATCH	BATCH		
ORIGINAL	0.045	0.009	0.165	0.015	1.28		
SPIKED SAMPLE	0.094	0.030	0.371	0.205	3.49		
SPIKE ADDED	0.050	0.020	0.200	0.200	2.00		
% RECOVERY	98.86%	106.62%	102.94%	95.30%	110.40%	NA	NA
QC CHECK							
FOUND	0.094	0.032	0.328	0.410	5.92		
TRUE	0.090	0.033	0.324	0.408	5.79		
% RECOVERY	104.06%	97.38%	101.15%	100.41%	102.33%	NA	NA
BLANK	<0.002	<0.001	<0.010	<0.010	<0.200	NA	NA

RPD = RELATIVE PERCENT DIFFERENCE.

NA = NOT APPLICABLE OR NOT AVAILABLE.

NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.

OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Damien Gadomski  
Project Manager





**Aquatic Research Inc.**

3927 Aurora Avenue N, Seattle, WA 98103

**P 206.632.2715 | F 206.632.2417**

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**SHEET 1 OF 1**

CLIENT: **CHAIN-OF-CUSTODY RECORD** Snohomish County - SWM

**SAMPLING DATE:** 9/28/11

SAMPLERS: W. BINGHOFF, M. POTT

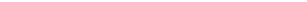
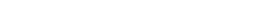
**PROJECT ID:** Ketchum

**CASE FILE NO.:**

DATA RECORDED BY:

## SAMPLE INFORMATION

[illegible]

Printed Name	Relinquished By	Date/Time	Received By	Date/Time
	Marianne Roth	9/28/11 16:40	Tam Meadows	9/28/11
Signature				1640
Affiliation	Snohomish County - SWM		ARF	

Printed Name	Relinquished By	Date/Time	Received By	Date/Time
Signature				
Affiliation				

Miscellaneous Notes (Hazardous Materials, Quick turn-around time, etc.):

**AQUATIC RESEARCH INCORPORATED****LABORATORY & CONSULTING SERVICES**

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

<b>CASE FILE NUMBER:</b>	<b>SNO005-90</b>	<b>PAGE 1</b>
<b>REPORT DATE:</b>	<b>10/26/11</b>	
<b>DATE SAMPLED:</b>	<b>10/12/11</b>	<b>DATE RECEIVED: 10/13/11</b>
<b>FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER</b>		
<b>SAMPLES FROM SNOHOMISH COUNTY SWM</b>		

**CASE NARRATIVE**

Four water samples were received by the laboratory in good condition and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on subsequent pages.

**SAMPLE DATA**

SAMPLE ID	TOTAL-P (mg/l)	SRP (mg/l)	AMMONIA (mg/l)	N03+N02 (mg/l)	TKN (mg/l)	CHLOR_a (ug/l)	PHAEO_a (ug/l)
KETCHUM 1M	0.426	0.281	<0.010	<0.010	2.20	184	11
KETCHUM 2M	0.411	0.267					
KETCHUM 4M	0.579	0.375					
KETCHUM 5M	2.48	2.40	7.46	0.012	13.8		

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PHONE: (206) 632-2715 FAX: (206) 632-2417

<b>CASE FILE NUMBER:</b>	<b>SNO005-90</b>	<b>PAGE 2</b>
<b>REPORT DATE:</b>	<b>10/26/11</b>	
<b>DATE SAMPLED:</b>	<b>10/12/11</b>	<b>DATE RECEIVED: 10/13/11</b>
<b>FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER</b>		
<b>SAMPLES FROM SNOHOMISH COUNTY SWM</b>		

**QA/QC DATA**

QC PARAMETER	TOTAL-P (mg/l)	SRP (mg/l)	AMMONIA (mg/l)	N03+N02 (mg/l)	TKN (mg/l)	CHLOR_a (ug/l)	PHAE0_a (ug/l)
METHOD	SM18 4500PF	SM18 4500PF	SM184500NH3H	SM184500N03F	EPA 351.1	SM18 10200H	SM18 10200H
DATE PREPARED	10/14/11					10/14/11	10/14/11
DATE ANALYZED	10/17/11	10/14/11	10/14/11	10/14/11	10/14/11	10/25/11	10/25/11
DETECTION LIMIT	0.002	0.001	0.010	0.010	0.200	0.1	0.1
DUPLICATE							
SAMPLE ID	BATCH	BATCH	BATCH	BATCH	BATCH	KETCHUM 1M	KETCHUM 1M
ORIGINAL	0.063	0.021	0.235	0.028	1.80	184	11
DUPLICATE	0.065	0.022	0.235	0.027	1.90	215	8.9
RPD	3.30%	6.18%	0.11%	5.84%	5.45%	15.55%	18.58%
SPIKE SAMPLE							
SAMPLE ID	BATCH	BATCH	BATCH	BATCH	BATCH		
ORIGINAL	0.063	0.021	0.235	0.028	1.80		
SPIKED SAMPLE	0.113	0.040	0.429	0.221	3.77		
SPIKE ADDED	0.050	0.020	0.200	0.200	2.00		
% RECOVERY	99.87%	95.93%	97.31%	96.14%	98.40%	NA	NA
QC CHECK							
FOUND	0.089	0.032	0.331	0.412	6.02		
TRUE	0.090	0.033	0.324	0.408	5.79		
% RECOVERY	98.59%	98.73%	102.20%	100.94%	103.93%	NA	NA
BLANK	<0.002	<0.001	<0.010	<0.010	<0.200	NA	NA

RPD = RELATIVE PERCENT DIFFERENCE.

NA = NOT APPLICABLE OR NOT AVAILABLE.

NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.

OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Damien Gadowski  
Project Manager

SN 0005-90  
June 2012

SAMPLERS: G. Williams

SHEET \_\_\_\_\_ OF \_\_\_\_\_  
PROJECT ID: KETCHUM  
CASE FILE NO.: \_\_\_\_\_  
DATA RECORDED BY: \_\_\_\_\_

## SAMPLE INFORMATION

[illegible]

Relinquished By	Date/Time	Received By	Date/Time
Printed Name <i>Gene Williams</i>	<i>10/13/11 8:25</i>	<i>PAULSEN CADORE</i>	<i>10/13/11 8:25</i>
Signature <i>Gene Williams</i>		<i>[Signature]</i>	
Affiliation <i>2nd COSWM</i>		<i>RCU</i>	

Relinquished By	Date/Time	Received By	Date/Time
Printed Name			
Signature			
Affiliation			

**Miscellaneous Notes (Hazardous Materials, Quick turn-around time, etc.):**

**AQUATIC RESEARCH INCORPORATED****LABORATORY & CONSULTING SERVICES****3927 AURORA AVENUE NORTH, SEATTLE, WA 98103****PHONE: (206) 632-2715 FAX: (206) 632-2417**

<b>CASE FILE NUMBER:</b>	<b>SNO005-93</b>	<b>PAGE 1</b>
<b>REPORT DATE:</b>	<b>11/01/11</b>	
<b>DATE SAMPLED:</b>	<b>10/21/11</b>	<b>DATE RECEIVED:</b> <b>10/21/11</b>
<b>FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER</b>		
<b>SAMPLES FROM SNOHOMISH COUNTY SWM</b>		

**CASE NARRATIVE**

Four water samples were received by the laboratory in good condition and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on subsequent pages.

**SAMPLE DATA**

SAMPLE ID	TOTAL-P (mg/l)	SRP (mg/l)	AMMONIA (mg/l)	N03+N02 (mg/l)	TKN (mg/l)	CHLOR_a (ug/l)	PHAEO_a (ug/l)
KETCHUM 1M	0.577	0.335	0.011	0.020	1.97	163	6.8
KETCHUM 2M	0.612	0.337					
KETCHUM 4M	0.618	0.344					
KETCHUM 5M	1.62	1.29	5.22	0.020	5.63		

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3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

<b>CASE FILE NUMBER:</b>	<b>SNO005-93</b>	<b>PAGE 2</b>
<b>REPORT DATE:</b>	<b>11/01/11</b>	
<b>DATE SAMPLED:</b>	<b>10/21/11</b>	<b>DATE RECEIVED: 10/21/11</b>
<b>FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER</b>		
<b>SAMPLES FROM SNOHOMISH COUNTY SWM</b>		

**QA/QC DATA**

QC PARAMETER	TOTAL-P (mg/L)	SRP (mg/L)	AMMONIA (mg/l)	N03+N02 (mg/l)	TKN (mg/l)	CHLOR_a (ug/l)	PHAE0_a (ug/l)
METHOD	SM18 4500PF	SM18 4500PF	SM184500NH3H	SM184500N03F	EPA 351.1	SM18 10200H	SM18 10200H
DATE PREPARED	10/28/11					10/21/11	10/21/11
DATE ANALYZED	10/31/11	10/21/11	10/21/11	10/21/11	10/28/11	11/01/11	11/01/11
DETECTION LIMIT	0.002	0.001	0.010	0.010	0.200	0.1	0.1
DUPLICATE							
SAMPLE ID	BATCH	BATCH	BATCH	BATCH	BATCH	KETCHUM 1M	KETCHUM 1M
ORIGINAL	0.012	0.036	0.216	0.045	1.18	163	6.8
DUPLICATE	0.010	0.036	0.217	0.043	1.18	162	8.1
RPD	14.25%	1.09%	0.20%	4.04%	0.13%	0.33%	17.14%
SPIKE SAMPLE							
SAMPLE ID	BATCH	BATCH	BATCH	BATCH	BATCH		
ORIGINAL	0.012	0.036	0.216	0.045	1.18		
SPIKED SAMPLE	0.063	0.056	0.417	0.242	3.20		
SPIKE ADDED	0.050	0.020	0.200	0.200	2.00		
% RECOVERY	102.09%	99.92%	100.51%	98.51%	101.00%	NA	NA
QC CHECK							
FOUND	0.090	0.033	0.329	0.414	5.82		
TRUE	0.090	0.033	0.324	0.408	5.79		
% RECOVERY	100.44%	98.85%	101.67%	101.52%	100.49%	NA	NA
BLANK	<0.002	<0.001	<0.010	<0.010	<0.200	NA	NA

RPD = RELATIVE PERCENT DIFFERENCE.

NA = NOT APPLICABLE OR NOT AVAILABLE.

NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.

OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Damien Gadomski  
Project Manager



**3927 Aurora Ave. N / Seattle, WA 98103 / (206) 632-2715**

SHEET 1 OF 1  
PROJECT ID: KETCHUM  
CASE FILE NO.: \_\_\_\_\_  
DATA RECORDED BY: \_\_\_\_\_

CLIENT: Snellomish County SWM  
SAMPLING DATE: Oct. 21, 2011  
SAMPLERS: G. Williams M. Burghoff

[illegible]

Printed Name	Relinquished By <i>Gene Willogans</i>	Date/Time <i>10/21/11 1:50</i>	Received By <i>Karinka Sosa</i>	Date/Time <i>10/21/11 1:50</i>
Signature	<i>Gene Willogans</i>		<i>Karinka Sosa</i>	
Affiliation	<i>Ind Co SWM</i>		<i>ARI</i>	

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name				
Signature				
Affiliation				

**Miscellaneous Notes (Hazardous Materials, Quick turn-around time, etc.):**

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## B HYDROLOGIC DATA

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In order to determine the hydrologic inputs to and outputs from Lake Ketchum, SWM conducted monitoring of the lake level, lake inlet, and precipitation data on a continuous basis with measurements occurring every 15 minutes or as precipitation occurred. Tetra Tech Inc. determined the lake inflows and outflows from these data as described below. A daily summary of lake level, flows, and precipitation is provided. Additional details on the hydrologic monitoring procedures can be found in the Appendix D of Snohomish County Lake Management Program Quality Assurance Management Plan (Snohomish County, 2011b).

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### B.1 FLOW CALCULATIONS FOR LAKE INLET AND OUTLET WEIRS

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#### B.1.1 INLET WEIR

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Surface runoff conveyed through the primary inlet stream into Lake Ketchum was measured using a sharp-crested V-notch weir plate and a pressure transducer. If the total included angle of the V-notch is known, flow can be calculated knowing only the height of the water-surface relative to the crest of the weir. The total included angle of the notch as measured by Snohomish County staff is 63 degrees (Figure B-1). The weir crest elevation was determined by County staff to be 0.70 feet, as measured on the gage plate installed in the weir pool. Water-surface elevations were measured by the pressure transducer at 15-minute intervals, and the depth of water over the weir crest was calculated.

FIGURE B-1: SHARP-CRESTED V-NOTCH WEIR AT PRIMARY INLET TO KETCHUM LAKE





The equation used to calculate flow through the thin-plate, V-notch weir for total included angles between 20 and 100 degrees is (White, 1999, p. 693):

$$Q = C_d * \tan \frac{\theta}{2} * g^{1/2} * H^{5/2}$$

Where:

- $Q$  = discharge through the v-notch (ft<sup>3</sup>/s)
- $C_d$  = weir discharge coefficient
- $\theta$  = total included angle of v-notch (63 degrees)
- $g$  = gravitational constant (32.2 ft/s<sup>2</sup>)
- $H$  = depth of flow over the weir crest (feet)

It is noted that for accurate measurements of flow, the weir discharge coefficient should be calibrated to measured flows and heads. However, when such calibration information is not available, an experimentally determined weir discharge coefficient can be used. The recommended value is approximately 0.44 for depths of flow over the weir crest ( $H$ ) greater than 50 mm (0.164 feet) (White, 1999, p. 693). For smaller depths, the effects of density, viscosity, and surface tension should be accounted for in the weir discharge coefficient. Since the water temperature was measured by the pressure transducer, these parameters were calculated in relation to water temperature (except surface tension as noted below), and the correction factor for the weir discharge coefficient is (White, 1999, p.693):

$$C_d = 0.44 + \frac{0.9}{(R_e * W_e)^{1/6}}$$

where:

- $C_d$  = weir discharge coefficient
- $R_e$  = Reynolds number (dimensionless)
- $W_e$  = Weber number (dimensionless)

$$R_e = \frac{\rho \sqrt{gH}^{3/2}}{\mu}$$

where:

- $R_e$  = Reynolds number (dimensionless)
- $\rho$  = water density (kg/m<sup>3</sup>, varies with water temperature)
- $g$  = gravitational constant (m/s<sup>2</sup>)
- $H$  = depth of flow over the weir crest (m)
- $\mu$  = coefficient of viscosity (kg/m/s, varies with water temperature)

$$W_e = \frac{\rho g H^2}{\phi}$$

where:

- $W_e$  = Weber number (dimensionless)
- $\rho$  = water density (kg/m<sup>3</sup>, varies with water temperature)
- $g$  = gravitational constant (m/s<sup>2</sup>)
- $H$  = depth of flow over the weir crest (m)
- $\phi$  = coefficient of surface tension (0.073 N/m, assumed constant for air-water interface at 20°C)

The application of these equations to the geometry of the weir and the measured water-surface elevations provides a reasonable basis for quantifying surface inflow in the primary inlet to Lake Ketchum. For the purposes of calculating a water budget, it was assumed that the calculated flow rate was constant over the 15-minute interval between measurements of water-surface elevation.

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### B.1.2 OUTLET WEIR

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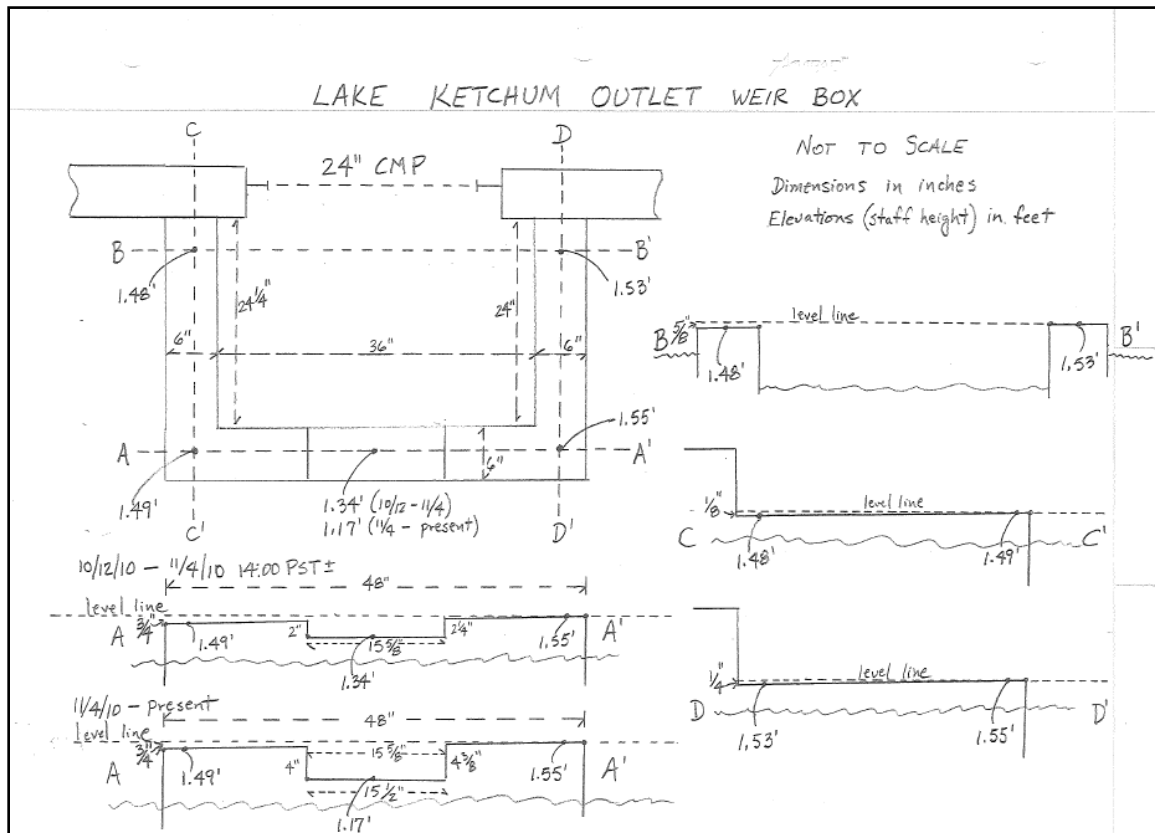
The primary means of surface outflow from Lake Ketchum is a notched riser box at the inlet of a 24-inch diameter, corrugated metal culvert (CMP) (Figure B-2 and Figure B-3). The front face of the box is approximately 24 inches from the inlet of the culvert; the sides of the box are approximately 36 inches apart. The walls of the box are 6-inch thick finished concrete. A metal mesh screen across the inlet of the culvert serves as a fish passage barrier. The dimensions of the box are not square, and the crest of the sill is not level. The notch in the front face of the box was  $2 \frac{1}{8}$ -inches deep (1.34 feet relative to local gage datum) and  $15 \frac{5}{8}$ -inches wide until November 4, 2010 14:00 PST, when the depth of the notch was increased to approximately  $4 \frac{3}{16}$  inches (1.17 feet relative to local gage datum) and the bottom width decreased to  $15 \frac{1}{2}$  inches.

There is some concern that higher flows may submerge flow over the weir (Figure B-4), particularly through the notch on the front of the box. The submergence could be caused by inlet control of the culvert, hydraulic resistance of the wire-mesh fish screen, and/or debris trapped against the fish screen. Unfortunately, since no water-surface elevations have been measured within the riser box, it cannot be determined under what conditions submergence occurs. The influence of submergence, if any, may change as a function of water-surface elevations, which could change in response to episodic debris trapped on the screen. For example, compare the water surface elevations in the riser box shown in Figure B-4 (lake water-surface elevation of 1.66 feet) to Figure B-5 (lake water-surface elevation of 1.70 feet). The greater lake level in Figure B-5 has a lower water-surface elevation in the riser box, indicating that for the conditions captured in Figure B-4 there is some “downstream” control on water-surface elevations that submerge flow over the weir. Therefore, the outflow from the lake was calculated assuming free-flowing conditions (i.e., no submergence). This estimate of outflow may exceed actual outflow, but it will serve as a reasonable upper bound on the surface outflow from Lake Ketchum.

FIGURE B-2: LAKE KETCHUM OUTLET STRUCTURE - NOTCHED RISER BOX AT INLET TO 24-INCH DIAMETER CMP (PHOTOGRAPH TAKEN NOVEMBER 2, 2010).



FIGURE B-3: LAKE KETCHUM OUTLET STRUCTURE DRAWING



Another issue that may contribute to the overestimation of outflow is the convergence of flow at the two corners of the riser box. As water flows over the front and side crests, it converges in the corners and probably reduces the effective length of the weir. This influence is localized and has not been quantified due to lack of information. Further, quantifying this influence would only decrease the calculated flow, which has already been noted as a reasonable upper bound on the outflow.

FIGURE B-4: LAKE KETCHUM OUTLET STRUCTURE, POTENTIALLY SUBMERGED WEIR FLOW THROUGH FRONT NOTCH AT LAKE LEVEL OF 1.66 FEET, MEASURED APRIL 11, 2011.



FIGURE B-5: APPARENTLY FREE-FLOW INTO THE RISER BOX WITH A LAKE LEVEL OF ABOUT 1.70 FEET AS MEASURED ON MARCH 17, 2011



The sill of the box riser is not level, so flow over the weir was calculated for segments of approximately level sill, and the total discharge was summed from the components. Due to the relatively low depths of flow over the sill (maximum of approximately 0.2 feet) and over the notch (maximum of approximately 0.5 feet), the weir flow was calculated assuming a broad-crested weir. A rounded leading edge of the sill was used in light of these relatively low flow depths.

Weir flow was calculated using the following equations (White 1999, p. 690):

$$Q = C_d * L * \sqrt{g} * H^{3/2}$$

where:

- 
- $Q$  = discharge over the weir (ft<sup>3</sup>/s)  
 $C_d$  = weir discharge coefficient (dimensionless)  
 $L$  = weir length (ft)  
 $g$  = gravitational constant (ft/s<sup>2</sup>)  
 $H$  = depth of flow over the weir crest (ft)

$$C_d = 0.544 \left( 1 - \frac{0.001 + 0.2 * (\epsilon/L)^{0.5}}{H/L} \right)^{1.5}$$

where:

- $C_d$  = weir discharge coefficient  
 $\epsilon$  = surface roughness of the crest (0.0032 feet for finished concrete)  
 $L$  = weir length (ft)  
 $H$  = depth of flow over the weir crest (ft)

The weir discharge coefficient approaches zero as the depth of flow over the weir crest ( $H$ ) approaches zero. To simplify computations, when  $H < 0.02$  feet,  $C_d$  was set to zero. It was assumed that the height of the riser box from the lake bed was at least 2 feet, thereby negating an effect of the weir height.

The inlet capacity of the culvert was calculated from estimated dimensions in the photographs to check that the culvert could convey the discharges calculated over the weir. The culvert capacity, assuming no appreciable resistance or obstruction in flow area by the fish screen and/or debris, exceeds the maximum calculated weir flow by almost a factor of 2, indicating that the culvert inlet should not limit the outflow from the lake for the conditions evaluated.

## B.2 DAILY SUMMARIES OF HYDROLOGIC DATA

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Daily summaries of the continuous lake level, inlet flow, outlet flow, and precipitation data are summarized in the following tables.

**Lake Ketchum Hydrologic Data: Oct. 2010 - Oct 2011**

Year	Date	Average of Lake Level Staff Height (feet)	Min of Lake Level Staff Height (feet)	Max of Lake Level Staff Height (feet)	Average of Outlet Total Q (cfs)	Min of Outlet Total Q (cfs)	Max of Outlet Total Q (cfs)	Sum of Outlet Vol (ft3/day)	Average of Inlet Q (cfs)	Min of Inlet Q (cfs)	Max of Inlet Q (cfs)	Sum of Inlet Vol (ft3/day)	Daily Precip Total (inches)
<b>2010</b>													
	<b>Oct</b>												
	13-Oct	1.39	1.37	1.40	0.02	0.01	0.04	1,948	0.01	0.01	0.01	633	
	14-Oct	1.38	1.36	1.39	0.02	0.00	0.03	1,388	0.01	0.00	0.01	540	
	15-Oct	1.37	1.35	1.39	0.01	0.00	0.03	691	0.00	0.00	0.01	413	
	16-Oct	1.36	1.34	1.38	0.00	0.00	0.02	244	0.00	0.00	0.01	402	
	17-Oct	1.34	1.33	1.35	0.00	0.00	0.00	0	0.00	0.00	0.01	375	
	18-Oct	1.34	1.33	1.35	0.00	0.00	0.00	0	0.00	0.00	0.00	240	
	19-Oct	1.33	1.32	1.34	0.00	0.00	0.00	0	0.00	0.00	0.00	162	
	20-Oct	1.32	1.31	1.34	0.00	0.00	0.00	0	0.00	0.00	0.00	194	0.01
	21-Oct	1.32	1.29	1.34	0.00	0.00	0.00	0	0.00	0.00	0.00	233	
	22-Oct	1.31	1.29	1.34	0.00	0.00	0.00	0	0.00	0.00	0.00	250	
	23-Oct	1.30	1.27	1.33	0.00	0.00	0.00	0	0.00	0.00	0.03	414	0.44
	24-Oct	1.33	1.29	1.36	0.00	0.00	0.00	7	0.01	0.01	0.03	1,023	0.47
	25-Oct	1.34	1.29	1.37	0.00	0.00	0.01	72	0.02	0.00	0.06	2,130	0.08
	26-Oct	1.35	1.32	1.39	0.00	0.00	0.03	86	0.01	0.00	0.01	464	0.05
	27-Oct	1.33	1.32	1.35	0.00	0.00	0.00	0	0.00	0.00	0.01	325	0.04
	28-Oct	1.33	1.32	1.35	0.00	0.00	0.00	0	0.00	0.00	0.00	251	0.04
	29-Oct	1.33	1.31	1.34	0.00	0.00	0.00	0	0.00	0.00	0.00	263	
	30-Oct	1.32	1.30	1.35	0.00	0.00	0.00	0	0.00	0.00	0.00	290	0.08
	31-Oct	1.34	1.31	1.37	0.00	0.00	0.01	54	0.02	0.01	0.03	1,420	0.20
	<b>Oct Total</b>	<b>1.34</b>	<b>1.27</b>	<b>1.40</b>	<b>0.00</b>	<b>0.00</b>	<b>0.04</b>	<b>4,490</b>	<b>0.01</b>	<b>0.00</b>	<b>0.06</b>	<b>10,019</b>	<b>1.41</b>
	<b>Nov</b>												
	1-Nov	1.36	1.32	1.39	0.01	0.00	0.03	563	0.02	0.01	0.07	2,066	0.28
	2-Nov	1.37	1.35	1.38	0.01	0.00	0.02	565	0.01	0.01	0.02	929	0.01
	3-Nov	1.36	1.34	1.38	0.00	0.00	0.02	266	0.01	0.01	0.01	624	0.01
	4-Nov	1.36	1.34	1.39	0.12	0.00	0.32	10,279	0.01	0.00	0.01	526	0.01
	5-Nov	1.35	1.34	1.36	0.27	0.25	0.29	22,973	0.01	0.00	0.02	859	0.11
	6-Nov	1.34	1.31	1.39	0.24	0.18	0.37	20,804	0.01	0.01	0.01	764	0.01
	7-Nov	1.38	1.35	1.45	0.33	0.27	0.55	28,557	0.07	0.02	0.43	6,260	1.45
	8-Nov	1.52	1.46	1.54	0.80	0.58	0.91	69,055	0.34	0.16	0.77	29,210	0.47

**Lake Ketchum Hydrologic Data: Oct. 2010 - Oct 2011**

Year	Date	Average of Lake Level Staff Height (feet)	Min of Lake Level Staff Height (feet)	Max of Lake Level Staff Height (feet)	Average of Outlet Total Q (cfs)	Min of Outlet Total Q (cfs)	Max of Outlet Total Q (cfs)	Sum of Outlet Vol (ft3/day)	Average of Inlet Q (cfs)	Min of Inlet Q (cfs)	Max of Inlet Q (cfs)	Sum of Inlet Vol (ft3/day)	Daily Precip Total (inches)
2010	Nov 9-Nov	1.51	1.48	1.54	0.76	0.64	0.91	63,986	0.12	0.09	0.16	10,353	0.04
	10-Nov	1.48	1.45	1.50	0.63	0.55	0.71	54,561	0.08	0.06	0.10	6,591	
	11-Nov	1.44	1.40	1.48	0.53	0.40	0.64	45,900	0.07	0.04	0.16	5,887	0.29
	12-Nov	1.44	1.42	1.46	0.52	0.46	0.58	44,699	0.09	0.08	0.10	7,723	0.01
	13-Nov	1.42	1.40	1.44	0.46	0.40	0.52	39,524	0.08	0.06	0.10	6,620	0.2
	14-Nov	1.42	1.41	1.44	0.46	0.43	0.52	40,030	0.12	0.09	0.14	10,763	0.18
	15-Nov	1.45	1.41	1.60	0.60	0.43	1.44	51,778	0.18	0.11	0.33	15,193	0.49
	16-Nov	1.57	1.54	1.59	1.14	0.91	1.37	98,507	0.23	0.16	0.30	19,965	0.02
	17-Nov	1.56	1.50	1.60	1.04	0.71	1.44	90,149	0.20	0.14	0.33	17,386	0.45
	18-Nov	1.57	1.56	1.59	1.15	1.06	1.33	99,616	0.28	0.22	0.34	24,585	0.13
	19-Nov	1.56	1.53	1.60	1.09	0.86	1.44	93,818	0.19	0.17	0.22	16,673	0.15
	20-Nov	1.56	1.55	1.59	1.08	0.98	1.33	93,255	0.19	0.16	0.21	16,223	0.02
	21-Nov	1.54	1.52	1.56	0.92	0.80	1.06	79,561	0.16	0.14	0.17	13,446	
	22-Nov	1.52	1.47	1.55	0.82	0.61	0.98	70,451	0.13	0.12	0.15	11,304	
	23-Nov	1.51	1.49	1.55	0.76	0.67	0.98	65,603	0.12	0.10	0.15	10,059	0.01
	24-Nov	1.48	1.46	1.50	0.63	0.58	0.71	54,636	0.09	0.08	0.10	8,017	
	25-Nov	1.49	1.45	1.52	0.67	0.55	0.80	58,006	0.11	0.09	0.15	9,389	0.3
	26-Nov	1.48	1.45	1.51	0.65	0.55	0.75	56,587	0.24	0.15	0.27	20,525	0.06
	27-Nov	1.47	1.45	1.49	0.61	0.55	0.67	52,589	0.21	0.17	0.26	18,170	0.09
	28-Nov	1.48	1.45	1.49	0.63	0.55	0.67	54,202	0.20	0.19	0.22	17,335	0.04
	29-Nov	1.47	1.44	1.50	0.60	0.52	0.71	51,705	0.17	0.15	0.20	14,388	0.05
	30-Nov	1.46	1.42	1.49	0.58	0.46	0.67	50,296	0.17	0.15	0.23	14,785	0.19
	<b>Nov Total</b>	<b>1.46</b>	<b>1.31</b>	<b>1.60</b>	<b>0.60</b>	<b>0.00</b>	<b>1.44</b>	<b>1,562,522</b>	<b>0.13</b>	<b>0.00</b>	<b>0.77</b>	<b>336,617</b>	<b>5.07</b>
	<b>Dec</b>												
	1-Dec	1.48	1.46	1.50	0.65	0.58	0.71	55,938	0.24	0.21	0.27	21,133	0.04
	2-Dec	1.47	1.46	1.48	0.61	0.58	0.64	52,330	0.19	0.16	0.22	16,569	
	3-Dec	1.46	1.45	1.47	0.58	0.55	0.61	49,882	0.16	0.15	0.17	13,607	
	4-Dec	1.45	1.43	1.47	0.55	0.49	0.61	47,722	0.14	0.13	0.15	12,072	
	5-Dec	1.43	1.42	1.45	0.49	0.46	0.55	42,260	0.13	0.13	0.15	11,544	
	6-Dec	1.42	1.39	1.45	0.46	0.37	0.55	40,113	0.13	0.12	0.15	11,232	
	7-Dec	1.42	1.39	1.47	0.46	0.37	0.61	39,703	0.13	0.12	0.15	11,320	0.05

**Lake Ketchum Hydrologic Data: Oct. 2010 - Oct 2011**

Year	Date	Average of Lake Level Staff Height (feet)	Min of Lake Level Staff Height (feet)	Max of Lake Level Staff Height (feet)	Average of Outlet Total Q (cfs)	Min of Outlet Total Q (cfs)	Max of Outlet Total Q (cfs)	Sum of Outlet Vol (ft3/day)	Average of Inlet Q (cfs)	Min of Inlet Q (cfs)	Max of Inlet Q (cfs)	Sum of Inlet Vol (ft3/day)	Daily Precip Total (inches)
2010	Dec 8-Dec	1.43	1.39	1.47	0.48	0.37	0.61	41,873	0.17	0.13	0.22	14,903	0.28
	9-Dec	1.41	1.35	1.48	0.43	0.27	0.64	37,118	0.20	0.16	0.33	17,506	0.34
	10-Dec	1.40	1.38	1.42	0.41	0.35	0.46	35,217	0.36	0.28	0.44	31,247	0.05
	11-Dec	1.41	1.37	1.47	0.43	0.32	0.61	36,941	0.29	0.22	0.63	25,358	0.51
	12-Dec	1.48	1.42	1.52	0.65	0.46	0.80	56,163	0.73	0.63	0.82	63,160	0.52
	13-Dec	1.55	1.52	1.59	0.96	0.80	1.33	82,930	0.67	0.58	0.75	57,843	0.2
	14-Dec	1.59	1.53	1.64	1.34	0.86	1.92	115,823	0.84	0.61	1.05	72,152	0.34
	15-Dec	1.58	1.54	1.60	1.19	0.91	1.44	103,198	0.50	0.41	0.63	42,889	0.03
	16-Dec	1.55	1.53	1.57	0.97	0.86	1.14	83,711	0.37	0.33	0.43	31,771	
	17-Dec	1.52	1.49	1.54	0.81	0.67	0.91	70,086	0.31	0.28	0.34	26,947	
	18-Dec	1.51	1.45	1.57	0.75	0.55	1.14	64,473	0.28	0.26	0.30	24,474	0.07
	19-Dec	1.49	1.47	1.51	0.68	0.61	0.75	59,052	0.27	0.26	0.30	23,538	0.02
	20-Dec	1.48	1.44	1.51	0.64	0.52	0.75	55,053	0.24	0.23	0.26	21,120	0.02
	21-Dec	1.47	1.43	1.49	0.61	0.49	0.67	52,888	0.23	0.21	0.24	19,899	0.04
	22-Dec	1.46	1.43	1.51	0.58	0.49	0.75	50,492	0.22	0.21	0.24	18,964	0.03
	23-Dec	1.45	1.42	1.48	0.56	0.46	0.64	48,172	0.20	0.20	0.22	17,607	0.04
	24-Dec	1.45	1.42	1.48	0.54	0.46	0.64	46,903	0.21	0.20	0.22	17,820	0.05
	25-Dec	1.44	1.42	1.47	0.53	0.46	0.61	45,828	0.22	0.20	0.23	19,054	0.06
	26-Dec	1.45	1.39	1.51	0.54	0.37	0.75	46,806	0.21	0.20	0.23	18,457	0.06
	27-Dec	1.44	1.40	1.46	0.52	0.40	0.58	44,521	0.19	0.17	0.22	16,223	
	28-Dec	1.43	1.41	1.45	0.50	0.43	0.55	42,775	0.18	0.16	0.20	15,617	
	29-Dec	1.43	1.40	1.46	0.48	0.40	0.58	41,742	0.18	0.16	0.20	15,684	0.08
	30-Dec	1.42	1.41	1.44	0.46	0.43	0.52	40,147	0.17	0.15	0.20	14,309	
	31-Dec	1.41	1.40	1.43	0.44	0.40	0.49	37,588	0.14	0.13	0.15	11,744	
	<b>Dec Total</b>	<b>1.46</b>	<b>1.35</b>	<b>1.64</b>	<b>0.62</b>	<b>0.27</b>	<b>2</b>	<b>1,667,443</b>	<b>0.27</b>	<b>0.12</b>	<b>1</b>	<b>735,763</b>	<b>3</b>
<b>2010 Total</b>		<b>1.43</b>	<b>1.27</b>	<b>1.64</b>	<b>0.47</b>	<b>0.00</b>	<b>1.92</b>	<b>3,234,455</b>	<b>0.16</b>	<b>0.00</b>	<b>1.05</b>	<b>1,082,399</b>	<b>9</b>
<b>2011</b>													
	<b>Jan</b>												
	1-Jan	1.41	1.40	1.42	0.43	0.40	0.46	36,904	0.12	0.11	0.14	10,618	
	2-Jan	1.41	1.39	1.42	0.42	0.37	0.46	36,223	0.11	0.10	0.13	9,755	
	3-Jan	1.40	1.39	1.42	0.40	0.37	0.46	34,888	0.11	0.10	0.12	9,094	



**Lake Ketchum Hydrologic Data: Oct. 2010 - Oct 2011**

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2011	Jan 4-Jan	1.39	1.38	1.41	0.38	0.35	0.43	33,206	0.10	0.10	0.12	8,993	0.01
	5-Jan	1.38	1.33	1.41	0.33	0.22	0.43	28,902	0.23	0.12	0.31	19,533	0.39
	6-Jan	1.30	1.27	1.42	0.16	0.10	0.46	14,099	0.32	0.28	0.44	27,867	0.4
	7-Jan	1.48	1.42	1.56	0.66	0.46	1.06	56,978	0.68	0.43	0.77	58,822	0.39
	8-Jan	1.53	1.49	1.56	0.87	0.67	1.06	75,317	0.49	0.43	0.61	42,616	0.09
	9-Jan	1.56	1.54	1.58	1.06	0.91	1.23	91,223	0.63	0.54	0.72	54,671	0.33
	10-Jan	1.55	1.53	1.57	1.01	0.86	1.14	87,595	0.48	0.39	0.65	41,569	
	11-Jan	1.55	1.53	1.58	0.98	0.86	1.23	84,893	0.35	0.33	0.41	30,629	
	12-Jan	1.55	1.52	1.58	1.01	0.80	1.23	87,470	0.43	0.34	0.58	37,247	0.25
	13-Jan	1.60	1.56	1.63	1.42	1.06	1.79	123,066	0.81	0.56	1.08	69,847	0.27
	14-Jan	1.61	1.57	1.65	1.54	1.14	2.05	133,006	0.53	0.44	0.67	45,415	0.06
	15-Jan	1.60	1.57	1.64	1.44	1.14	1.92	124,086	0.42	0.36	0.67	36,043	0.39
	16-Jan	1.66	1.59	1.70	2.22	1.33	2.76	191,537	1.16	0.67	1.61	99,910	0.55
	17-Jan	1.77	1.68	1.85	3.87	2.47	5.42	334,177	2.41	0.96	4.15	207,894	1.06
	18-Jan	1.71	1.68	1.76	2.98	2.47	3.74	257,809	1.06	0.93	1.38	91,734	0.15
	19-Jan	1.65	1.62	1.68	2.07	1.67	2.47	178,700	0.76	0.63	0.99	65,820	
	20-Jan	1.62	1.59	1.64	1.64	1.33	1.92	141,701	0.62	0.56	0.75	53,232	0.26
	21-Jan	1.72	1.61	1.80	3.05	1.55	4.46	263,916	2.20	0.75	3.68	189,718	1.05
	22-Jan	1.72	1.68	1.76	3.05	2.47	3.74	263,112	1.17	0.90	1.73	100,904	
	23-Jan	1.67	1.64	1.69	2.26	1.92	2.61	195,676	0.87	0.77	0.93	74,948	0.14
	24-Jan	1.66	1.64	1.69	2.17	1.92	2.61	187,788	1.04	0.77	1.28	89,611	0.4
	25-Jan	1.65	1.62	1.67	2.00	1.67	2.32	172,553	0.81	0.67	1.05	69,930	0.01
	26-Jan	1.62	1.60	1.63	1.62	1.44	1.79	140,079	0.61	0.54	0.70	52,968	0.01
	27-Jan	1.59	1.58	1.61	1.38	1.23	1.55	119,278	0.52	0.48	0.56	45,047	
	28-Jan	1.58	1.53	1.62	1.22	0.86	1.67	105,361	0.47	0.43	0.52	40,748	
	29-Jan	1.58	1.56	1.59	1.20	1.06	1.33	103,562	0.47	0.43	0.58	40,890	0.2
	30-Jan	1.58	1.56	1.60	1.23	1.06	1.44	106,021	0.50	0.44	0.58	43,575	
	31-Jan	1.56	1.54	1.58	1.06	0.91	1.23	91,335	0.41	0.39	0.44	35,815	
	<b>Jan Total</b>	<b>1.57</b>	<b>1.27</b>	<b>1.85</b>	<b>1.46</b>	<b>0.10</b>	<b>5.42</b>	<b>3,900,459</b>	<b>0.67</b>	<b>0.10</b>	<b>4.15</b>	<b>1,805,463</b>	<b>6.41</b>
	<b>Feb</b>												
	1-Feb	1.55	1.54	1.56	0.96	0.91	1.06	83,089	0.43	0.38	0.56	36,851	

**Lake Ketchum Hydrologic Data: Oct. 2010 - Oct 2011**

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2011	Feb 2-Feb	1.53	1.52	1.55	0.88	0.80	0.98	75,620	0.37	0.34	0.41	31,662	
	3-Feb	1.53	1.50	1.54	0.83	0.71	0.91	71,983	0.36	0.34	0.38	31,138	0.13
	4-Feb	1.56	1.51	1.59	1.06	0.75	1.33	91,418	0.59	0.38	0.67	50,564	0.32
	5-Feb	1.56	1.54	1.58	1.04	0.91	1.23	90,129	0.44	0.39	0.56	38,409	0.01
	6-Feb	1.55	1.52	1.58	0.99	0.80	1.23	85,660	0.46	0.39	0.52	39,490	0.24
	7-Feb	1.55	1.50	1.61	1.01	0.71	1.55	86,987	0.48	0.41	0.54	41,295	0.01
	8-Feb	1.54	1.52	1.56	0.91	0.80	1.06	78,212	0.37	0.34	0.41	32,383	
	9-Feb	1.52	1.51	1.54	0.81	0.75	0.91	69,598	0.32	0.30	0.34	27,677	
	10-Feb	1.51	1.49	1.52	0.74	0.67	0.80	63,597	0.30	0.28	0.33	26,344	
	11-Feb	1.50	1.48	1.53	0.73	0.64	0.86	62,763	0.29	0.28	0.30	25,291	
	12-Feb	1.50	1.42	1.57	0.74	0.46	1.14	63,646	0.29	0.26	0.30	24,850	0.08
	13-Feb	1.50	1.48	1.52	0.69	0.64	0.80	59,836	0.31	0.28	0.33	26,526	0.02
	14-Feb	1.50	1.39	1.57	0.70	0.37	1.14	60,831	0.35	0.27	0.46	29,909	0.21
	15-Feb	1.50	1.46	1.52	0.71	0.58	0.80	61,611	0.34	0.30	0.44	29,315	0.02
	16-Feb	1.49	1.45	1.53	0.68	0.55	0.86	58,843	0.29	0.26	0.31	25,008	0.15
	17-Feb	1.50	1.46	1.52	0.70	0.58	0.80	60,380	0.38	0.31	0.43	32,425	0.09
	18-Feb	1.48	1.47	1.50	0.66	0.61	0.71	56,818	0.31	0.27	0.34	26,537	
	19-Feb	1.47	1.45	1.49	0.62	0.55	0.67	53,971	0.25	0.23	0.27	21,790	
	20-Feb	1.46	1.45	1.48	0.59	0.55	0.64	51,091	0.23	0.21	0.26	20,163	
	21-Feb	1.45	1.43	1.53	0.56	0.49	0.86	48,565	0.23	0.21	0.27	19,999	0.1
	22-Feb	1.49	1.45	1.54	0.69	0.55	0.91	59,917	0.46	0.26	0.65	40,131	0.39
	23-Feb	1.55	1.52	1.60	1.01	0.80	1.44	87,692	0.49	0.41	0.56	42,387	0.04
	24-Feb	1.56	1.55	1.58	1.09	0.98	1.23	94,520	0.43	0.39	0.48	36,984	0.06
	25-Feb	1.56	1.54	1.58	1.06	0.91	1.23	91,292	0.35	0.31	0.41	30,423	0.32
	26-Feb	1.55	1.52	1.58	0.97	0.80	1.23	83,793	0.29	0.27	0.34	25,227	
	27-Feb	1.57	1.55	1.59	1.10	0.98	1.33	95,051	0.35	0.28	0.65	30,200	0.56
	28-Feb	1.59	1.55	1.61	1.29	0.98	1.55	111,492	1.10	0.65	1.42	94,981	0.34
	<b>Feb Total</b>	<b>1.52</b>	<b>1.39</b>	<b>1.61</b>	<b>0.85</b>	<b>0.37</b>	<b>1.55</b>	<b>2,058,404</b>	<b>0.39</b>	<b>0.21</b>	<b>1.42</b>	<b>937,959</b>	<b>3.09</b>
	<b>Mar</b>												
	1-Mar	1.61	1.59	1.62	1.51	1.33	1.67	130,138	0.86	0.75	1.18	74,428	0.02
	2-Mar	1.61	1.49	1.70	1.54	0.67	2.76	133,356	0.77	0.63	0.85	66,255	0.1

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2011	Mar 3-Mar	1.61	1.57	1.65	1.58	1.14	2.05	136,929	0.54	0.50	0.63	46,869	0.08
	4-Mar	1.64	1.61	1.68	1.91	1.55	2.47	165,004	0.50	0.44	0.63	43,482	0.19
	5-Mar	1.66	1.64	1.68	2.15	1.92	2.47	185,684	0.57	0.50	0.63	49,335	0.07
	6-Mar	1.66	1.61	1.70	2.14	1.55	2.76	184,603	0.46	0.41	0.52	39,574	0.01
	7-Mar	1.62	1.58	1.66	1.66	1.23	2.18	143,161	0.38	0.33	0.43	33,008	
	8-Mar	1.57	1.55	1.60	1.18	0.98	1.44	101,550	0.36	0.31	0.41	31,352	0.11
	9-Mar	1.56	1.50	1.62	1.05	0.71	1.67	90,838	0.36	0.34	0.41	31,013	0.28
	10-Mar	1.56	1.49	1.63	1.10	0.67	1.79	94,964	0.51	0.44	0.58	43,667	0.13
	11-Mar	1.56	1.51	1.59	1.03	0.75	1.33	89,069	0.40	0.36	0.46	34,425	0.01
	12-Mar	1.58	1.53	1.63	1.25	0.86	1.79	108,303	0.71	0.36	1.18	61,209	0.54
	13-Mar	1.61	1.56	1.67	1.50	1.06	2.32	129,890	0.70	0.61	0.82	60,631	0.26
	14-Mar	1.62	1.57	1.69	1.65	1.14	2.61	142,719	0.73	0.52	0.88	62,660	0.11
	15-Mar	1.61	1.56	1.67	1.59	1.06	2.32	137,471	0.65	0.52	0.85	56,583	0.25
	16-Mar	1.64	1.60	1.69	1.97	1.44	2.61	170,322	0.85	0.65	1.02	73,014	0.68
	17-Mar	1.70	1.67	1.73	2.78	2.32	3.24	239,850	1.03	0.67	1.42	89,272	0.06
	18-Mar	1.65	1.63	1.68	2.09	1.79	2.47	180,499	0.59	0.52	0.77	50,960	0.37
	19-Mar	1.65	1.62	1.68	2.11	1.67	2.47	181,945	0.84	0.58	1.08	72,917	0.02
	20-Mar	1.63	1.61	1.65	1.81	1.55	2.05	156,376	0.53	0.48	0.61	45,362	
	21-Mar	1.62	1.60	1.63	1.62	1.44	1.79	140,137	0.46	0.43	0.50	39,377	0.13
	22-Mar	1.61	1.57	1.62	1.50	1.14	1.67	129,283	0.44	0.39	0.48	38,190	0.01
	23-Mar	1.59	1.57	1.63	1.34	1.14	1.79	115,456	0.38	0.34	0.41	32,599	
	24-Mar	1.58	1.56	1.61	1.24	1.06	1.55	107,181	0.34	0.31	0.36	29,485	
	25-Mar	1.57	1.56	1.60	1.18	1.06	1.44	102,044	0.33	0.30	0.38	28,701	0.06
	26-Mar	1.56	1.55	1.58	1.08	0.98	1.23	93,718	0.30	0.27	0.33	26,240	0.09
	27-Mar	1.56	1.53	1.59	1.07	0.86	1.33	92,744	0.31	0.28	0.33	26,708	0.01
	28-Mar	1.56	1.51	1.60	1.06	0.75	1.44	91,920	0.28	0.26	0.30	23,931	0.06
	29-Mar	1.55	1.51	1.58	0.96	0.75	1.23	83,088	0.26	0.24	0.31	22,876	0.15
	30-Mar	1.60	1.53	1.68	1.50	0.86	2.47	129,311	0.82	0.30	1.38	70,571	0.98
	31-Mar	1.68	1.64	1.70	2.42	1.92	2.76	208,904	1.14	0.72	1.45	98,209	0.2
	<b>Mar Total</b>	<b>1.61</b>	<b>1.49</b>	<b>1.73</b>	<b>1.57</b>	<b>0.67</b>	<b>3.24</b>	<b>4,196,455</b>	<b>0.56</b>	<b>0.24</b>	<b>1.45</b>	<b>1,502,903</b>	<b>4.98</b>
	<b>Apr</b>												

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2011	Apr 1-Apr	1.68	1.64	1.73	2.53	1.92	3.24	218,684	1.12	0.61	1.69	97,195	0.71
	2-Apr	1.71	1.68	1.75	2.96	2.47	3.57	255,335	1.20	0.80	1.61	103,702	0.17
	3-Apr	1.66	1.63	1.69	2.21	1.79	2.61	190,688	0.64	0.52	0.80	55,061	0.78
	4-Apr	1.66	1.62	1.71	2.19	1.67	2.92	189,582	0.94	0.52	1.73	80,813	0.06
	5-Apr	1.71	1.67	1.74	2.88	2.32	3.40	248,603	1.17	0.88	1.77	101,530	0.1
	6-Apr	1.68	1.65	1.71	2.45	2.05	2.92	211,708	0.75	0.63	0.88	65,228	
	7-Apr	1.65	1.62	1.67	1.99	1.67	2.32	172,173	0.56	0.50	0.63	48,324	
	8-Apr	1.63	1.61	1.66	1.75	1.55	2.18	151,153	0.48	0.44	0.52	41,482	
	9-Apr	1.61	1.57	1.64	1.54	1.14	1.92	133,419	0.42	0.39	0.46	36,710	
	10-Apr	1.59	1.54	1.64	1.37	0.91	1.92	118,380	0.39	0.38	0.43	34,084	0.12
	11-Apr	1.63	1.59	1.66	1.79	1.33	2.18	154,905	0.69	0.41	0.93	59,943	0.38
	12-Apr	1.63	1.60	1.65	1.75	1.44	2.05	150,830	0.49	0.43	0.56	42,108	
	13-Apr	1.60	1.57	1.63	1.44	1.14	1.79	124,287	0.40	0.36	0.43	34,239	0.04
	14-Apr	1.59	1.56	1.62	1.33	1.06	1.67	115,038	0.40	0.34	0.48	34,629	0.2
	15-Apr	1.59	1.58	1.60	1.33	1.23	1.44	114,961	0.41	0.38	0.48	35,493	0.06
	16-Apr	1.59	1.57	1.61	1.34	1.14	1.55	115,661	0.41	0.38	0.44	35,114	0.1
	17-Apr	1.59	1.56	1.62	1.30	1.06	1.67	112,009	0.36	0.31	0.41	30,992	
	18-Apr	1.59	1.55	1.63	1.31	0.98	1.79	113,151	0.32	0.28	0.36	27,927	0.04
	19-Apr	1.57	1.55	1.61	1.15	0.98	1.55	99,463	0.29	0.27	0.31	25,395	
	20-Apr	1.55	1.52	1.58	0.99	0.80	1.23	85,516	0.26	0.23	0.28	22,335	
	21-Apr	1.54	1.52	1.58	0.93	0.80	1.23	79,974	0.26	0.23	0.30	22,427	0.09
	22-Apr	1.53	1.51	1.57	0.88	0.75	1.14	75,793	0.24	0.22	0.26	20,416	
	23-Apr	1.53	1.50	1.56	0.84	0.71	1.06	72,538	0.22	0.20	0.23	18,644	
	24-Apr	1.53	1.51	1.56	0.88	0.75	1.06	75,777	0.19	0.17	0.21	16,832	0.01
	25-Apr	1.55	1.52	1.59	1.02	0.80	1.33	87,772	0.31	0.19	0.50	26,989	0.55
	26-Apr	1.58	1.56	1.61	1.26	1.06	1.55	108,817	0.34	0.27	0.46	29,130	0.09
	27-Apr	1.57	1.53	1.60	1.15	0.86	1.44	98,969	0.27	0.23	0.33	23,345	0.22
	28-Apr	1.58	1.55	1.61	1.19	0.98	1.55	102,580	0.32	0.27	0.36	28,078	0.08
	29-Apr	1.55	1.52	1.57	0.97	0.80	1.14	84,008	0.24	0.21	0.28	20,458	0
	30-Apr	1.53	1.50	1.56	0.84	0.71	1.06	72,913	0.20	0.19	0.22	17,487	
	<b>Apr Total</b>	<b>1.60</b>	<b>1.50</b>	<b>1.75</b>	<b>1.52</b>	<b>0.71</b>	<b>3.57</b>	<b>3,934,687</b>	<b>0.48</b>	<b>0.17</b>	<b>1.77</b>	<b>1,236,110</b>	<b>3.8</b>

**Lake Ketchum Hydrologic Data: Oct. 2010 - Oct 2011**

Year	Date	Average of Lake Level Staff Height (feet)	Min of Lake Level Staff Height (feet)	Max of Lake Level Staff Height (feet)	Average of Outlet Total Q (cfs)	Min of Outlet Total Q (cfs)	Max of Outlet Total Q (cfs)	Sum of Outlet Vol (ft3/day)	Average of Inlet Q (cfs)	Min of Inlet Q (cfs)	Max of Inlet Q (cfs)	Sum of Inlet Vol (ft3/day)	Daily Precip Total (inches)
2011	May												
	1-May	1.51	1.49	1.54	0.74	0.67	0.91	64,356	0.18	0.15	0.20	15,225	
	2-May	1.51	1.48	1.55	0.77	0.64	0.98	66,602	0.27	0.15	0.48	22,975	0.44
	3-May	1.54	1.51	1.58	0.92	0.75	1.23	79,577	0.29	0.21	0.41	25,439	0.01
	4-May	1.53	1.51	1.56	0.83	0.75	1.06	72,135	0.20	0.17	0.23	17,151	
	5-May	1.51	1.50	1.53	0.77	0.71	0.86	66,517	0.18	0.16	0.22	15,447	0.13
	6-May	1.52	1.50	1.55	0.82	0.71	0.98	71,085	0.26	0.19	0.39	22,094	0.33
	7-May	1.58	1.53	1.62	1.25	0.86	1.67	107,660	0.70	0.34	1.21	60,318	0.61
	8-May	1.61	1.58	1.63	1.51	1.23	1.79	130,852	0.54	0.36	0.88	46,836	0.04
	9-May	1.57	1.55	1.60	1.17	0.98	1.44	100,940	0.31	0.27	0.36	27,052	
	10-May	1.55	1.53	1.59	1.02	0.86	1.33	87,883	0.26	0.23	0.28	22,332	
	11-May	1.56	1.51	1.61	1.04	0.75	1.55	90,232	0.40	0.21	0.88	34,396	0.71
	12-May	1.66	1.60	1.77	2.25	1.44	3.92	194,311	0.80	0.46	1.05	68,963	0.22
	13-May	1.70	1.63	1.76	2.74	1.79	3.74	236,768	0.37	0.30	0.46	32,066	
	14-May	1.61	1.58	1.64	1.50	1.23	1.92	129,841	0.31	0.27	0.50	26,977	0.37
	15-May	1.67	1.60	1.76	2.38	1.44	3.74	205,652	1.07	0.52	1.49	92,618	0.64
	16-May	1.70	1.66	1.74	2.70	2.18	3.40	233,456	0.79	0.58	1.21	68,066	0.03
	17-May	1.64	1.60	1.67	1.86	1.44	2.32	160,718	0.47	0.36	0.58	40,271	
	18-May	1.60	1.58	1.64	1.44	1.23	1.92	124,451	0.33	0.28	0.36	28,462	
	19-May	1.58	1.55	1.61	1.20	0.98	1.55	103,469	0.27	0.16	0.48	23,082	
	20-May	1.55	1.53	1.58	1.01	0.86	1.23	87,612	0.24	0.23	0.26	20,856	
	21-May	1.55	1.52	1.58	0.97	0.80	1.23	84,168	0.23	0.22	0.24	20,284	0.02
	22-May	1.56	1.54	1.58	1.07	0.91	1.23	92,028	0.24	0.22	0.24	20,493	0.06
	23-May	1.54	1.52	1.57	0.94	0.80	1.14	81,165	0.21	0.19	0.23	17,869	
	24-May	1.52	1.50	1.54	0.80	0.71	0.91	68,066	0.18	0.15	0.20	15,256	0
	25-May	1.51	1.49	1.54	0.75	0.67	0.91	64,867	0.19	0.15	0.24	16,126	0.19
	26-May	1.54	1.52	1.57	0.92	0.80	1.14	79,654	0.27	0.21	0.33	23,595	0.18
	27-May	1.55	1.52	1.59	1.01	0.80	1.33	86,845	0.21	0.17	0.24	18,017	0.2
	28-May	1.56	1.55	1.59	1.09	0.98	1.33	94,275	0.19	0.15	0.23	16,074	0.02
	29-May	1.57	1.56	1.60	1.13	1.06	1.44	97,391	0.15	0.14	0.16	13,030	
	30-May	1.57	1.55	1.60	1.15	0.98	1.44	99,545	0.14	0.13	0.15	12,000	0.01

**Lake Ketchum Hydrologic Data: Oct. 2010 - Oct 2011**

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2011	May 31-May	1.57	1.56	1.60	1.16	1.06	1.44	100,273	0.13	0.12	0.15	11,456	0.01
	<b>May Total</b>	<b>1.57</b>	<b>1.48</b>	<b>1.77</b>	<b>1.26</b>	<b>0.64</b>	<b>3.92</b>	<b>3,362,393</b>	<b>0.33</b>	<b>0.12</b>	<b>1.49</b>	<b>894,826</b>	<b>4.22</b>
	<b>Jun</b>												
	1-Jun	1.55	1.53	1.57	0.98	0.86	1.14	84,853	0.13	0.12	0.15	11,160	
	2-Jun	1.55	1.53	1.56	0.95	0.86	1.06	81,919	0.13	0.12	0.14	10,824	0.03
	3-Jun	1.55	1.54	1.61	1.02	0.91	1.55	87,882	0.12	0.10	0.14	10,047	
	4-Jun	1.57	1.54	1.61	1.13	0.91	1.55	97,637	0.09	0.08	0.11	8,171	
	5-Jun	1.57	1.55	1.60	1.13	0.98	1.44	97,799	0.08	0.07	0.10	6,910	
	6-Jun	1.55	1.53	1.58	1.02	0.86	1.23	88,028	0.07	0.06	0.08	6,027	
	7-Jun	1.55	1.52	1.57	0.96	0.80	1.14	82,868	0.09	0.07	0.12	7,360	0.16
	8-Jun	1.53	1.51	1.55	0.85	0.75	0.98	73,239	0.08	0.07	0.09	6,956	0.01
	9-Jun	1.51	1.49	1.54	0.75	0.67	0.91	64,701	0.07	0.06	0.08	6,115	
	10-Jun	1.49	1.48	1.51	0.68	0.64	0.75	58,512	0.06	0.05	0.07	5,250	
	11-Jun	1.48	1.47	1.51	0.64	0.61	0.75	55,400	0.06	0.05	0.06	4,897	
	12-Jun	1.47	1.45	1.50	0.61	0.55	0.71	52,594	0.05	0.04	0.06	4,192	
	13-Jun	1.47	1.45	1.51	0.61	0.55	0.75	52,893	0.05	0.04	0.06	4,533	0.07
	14-Jun	1.46	1.45	1.48	0.58	0.55	0.64	50,515	0.05	0.04	0.07	4,365	0.08
	15-Jun	1.47	1.45	1.50	0.62	0.55	0.71	53,388	0.06	0.06	0.08	5,605	0.13
	16-Jun	1.47	1.45	1.50	0.61	0.55	0.71	52,592	0.05	0.04	0.06	4,485	
	17-Jun	1.46	1.44	1.49	0.57	0.52	0.67	49,331	0.04	0.03	0.05	3,349	
	18-Jun	1.45	1.44	1.47	0.55	0.52	0.61	47,669	0.05	0.03	0.06	4,181	0.17
	19-Jun	1.45	1.44	1.47	0.56	0.52	0.61	48,451	0.05	0.04	0.05	4,327	0.03
	20-Jun	1.45	1.44	1.49	0.56	0.52	0.67	48,368	0.04	0.03	0.05	3,630	
	21-Jun	1.45	1.43	1.48	0.55	0.49	0.64	47,254	0.03	0.02	0.04	2,770	
	22-Jun	1.44	1.42	1.45	0.50	0.46	0.55	43,505	0.03	0.00	0.04	2,637	0
	23-Jun	1.42	1.38	1.46	0.46	0.35	0.58	39,415	0.03	0.02	0.04	2,580	0.05
	24-Jun	1.41	1.38	1.45	0.42	0.35	0.55	35,894	0.03	0.02	0.03	2,264	0.01
	25-Jun	1.40	1.38	1.44	0.39	0.35	0.52	33,539	0.02	0.02	0.03	1,878	
	26-Jun	1.39	1.37	1.43	0.37	0.32	0.49	31,838	0.02	0.02	0.02	1,731	
	27-Jun	1.38	1.37	1.41	0.36	0.32	0.43	30,876	0.02	0.02	0.02	1,631	
	28-Jun	1.38	1.37	1.41	0.35	0.32	0.43	29,838	0.02	0.02	0.02	1,650	0.01

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2011	Jun 29-Jun	1.38	1.36	1.41	0.35	0.29	0.43	30,314	0.02	0.02	0.03	1,976	0.14
	30-Jun	1.38	1.37	1.40	0.36	0.32	0.40	30,806	0.02	0.02	0.02	1,752	0.02
	<b>Jun Total</b>	<b>1.47</b>	<b>1.36</b>	<b>1.61</b>	<b>0.65</b>	<b>0.29</b>	<b>1.55</b>	<b>1,681,915</b>	<b>0.06</b>	<b>0.00</b>	<b>0.15</b>	<b>143,254</b>	<b>0.91</b>
	<b>Jul</b>												
	1-Jul	1.39	1.37	1.44	0.37	0.32	0.52	31,929	0.02	0.01	0.02	1,386	
	2-Jul	1.38	1.35	1.42	0.34	0.27	0.46	29,045	0.01	0.01	0.02	1,156	
	3-Jul	1.38	1.35	1.42	0.35	0.27	0.46	29,876	0.02	0.01	0.03	1,435	0.11
	4-Jul	1.38	1.36	1.43	0.36	0.29	0.49	30,673	0.01	0.01	0.02	1,148	
	5-Jul	1.39	1.36	1.44	0.37	0.29	0.52	31,686	0.01	0.01	0.02	986	
	6-Jul	1.37	1.34	1.41	0.32	0.25	0.43	27,864	0.01	0.01	0.02	910	
	7-Jul	1.36	1.34	1.37	0.29	0.25	0.32	24,687	0.01	0.01	0.02	1,115	0.09
	8-Jul	1.36	1.34	1.41	0.31	0.25	0.43	26,461	0.01	0.01	0.03	1,189	0.11
	9-Jul	1.36	1.34	1.41	0.30	0.25	0.43	25,743	0.01	0.01	0.01	804	
	10-Jul	1.35	1.33	1.39	0.28	0.22	0.37	24,190	0.01	0.01	0.01	715	
	11-Jul	1.35	1.33	1.38	0.26	0.22	0.35	22,717	0.01	0.00	0.01	676	
	12-Jul	1.34	1.32	1.38	0.25	0.20	0.35	21,217	0.01	0.00	0.01	615	
	13-Jul	1.33	1.31	1.37	0.23	0.18	0.32	19,771	0.01	0.00	0.01	549	
	14-Jul	1.33	1.31	1.35	0.22	0.18	0.27	19,227	0.01	0.01	0.02	872	0.02
	15-Jul	1.33	1.31	1.36	0.23	0.18	0.29	19,715	0.01	0.00	0.01	734	0.06
	16-Jul	1.34	1.32	1.40	0.25	0.20	0.40	21,804	0.01	0.01	0.02	1,070	0.15
	17-Jul	1.34	1.33	1.35	0.26	0.22	0.27	22,100	0.01	0.01	0.02	1,026	0.09
	18-Jul	1.35	1.33	1.39	0.28	0.22	0.37	23,911	0.01	0.00	0.01	718	
	19-Jul	1.34	1.33	1.36	0.24	0.22	0.29	20,936	0.01	0.00	0.01	555	0.01
	20-Jul	1.34	1.32	1.37	0.24	0.20	0.32	20,397	0.01	0.00	0.01	520	0.01
	21-Jul	1.33	1.32	1.35	0.23	0.20	0.27	19,767	0.01	0.00	0.01	688	0.13
	22-Jul	1.33	1.32	1.38	0.23	0.20	0.35	20,156	0.01	0.00	0.01	508	
	23-Jul	1.33	1.31	1.37	0.22	0.18	0.32	19,287	0.00	0.00	0.01	285	
	24-Jul	1.32	1.30	1.36	0.21	0.16	0.29	18,109	0.00	0.00	0.00	168	
	25-Jul	1.32	1.30	1.33	0.19	0.16	0.22	16,337	0.01	0.00	0.02	450	0.16
	26-Jul	1.32	1.31	1.33	0.20	0.18	0.22	17,280	0.01	0.00	0.01	505	
	27-Jul	1.31	1.29	1.34	0.18	0.14	0.25	15,278	0.00	0.00	0.01	277	0

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2011	Jul 28-Jul	1.30	1.29	1.35	0.16	0.14	0.27	14,228	0.00	0.00	0.00	177	
	29-Jul	1.30	1.28	1.34	0.16	0.12	0.25	13,810	0.00	0.00	0.00	158	
	30-Jul	1.29	1.28	1.33	0.15	0.12	0.22	12,713	0.00	0.00	0.00	79	
	31-Jul	1.30	1.28	1.33	0.15	0.12	0.22	12,947	0.00	0.00	0.00	93	
	<b>Jul Total</b>	<b>1.34</b>	<b>1.28</b>	<b>1.44</b>	<b>0.25</b>	<b>0.12</b>	<b>0.52</b>	<b>673,859</b>	<b>0.01</b>	<b>0.00</b>	<b>0.03</b>	<b>21,570</b>	<b>0.94</b>
	<b>Aug</b>												
	1-Aug	1.28	1.26	1.33	0.13	0.08	0.22	11,087	0.00	0.00	0.00	23	
	2-Aug	1.28	1.26	1.33	0.12	0.08	0.22	10,361	0.00	0.00	0.00	0	
	3-Aug	1.28	1.26	1.32	0.12	0.08	0.20	10,268	0.00	0.00	0.00	0	
	4-Aug	1.27	1.25	1.32	0.10	0.07	0.20	8,576	0.00	0.00	0.00	0	
	5-Aug	1.26	1.25	1.28	0.08	0.07	0.12	7,020	0.00	0.00	0.00	0	
	6-Aug	1.26	1.25	1.30	0.09	0.07	0.16	7,385	0.00	0.00	0.00	0	
	7-Aug	1.26	1.23	1.30	0.08	0.04	0.16	6,602	0.00	0.00	0.00	0	
	8-Aug	1.25	1.23	1.28	0.06	0.04	0.12	5,477	0.00	0.00	0.00	0	
	9-Aug	1.24	1.22	1.26	0.05	0.03	0.08	4,212	0.00	0.00	0.00	0	
	10-Aug	1.23	1.22	1.27	0.04	0.03	0.10	3,728	0.00	0.00	0.00	0	
	11-Aug	1.23	1.22	1.27	0.05	0.03	0.10	4,011	0.00	0.00	0.00	0	
	12-Aug	1.23	1.21	1.27	0.04	0.02	0.10	3,306	0.00	0.00	0.00	0	
	13-Aug	1.22	1.21	1.24	0.03	0.02	0.05	2,716	0.00	0.00	0.00	0	
	14-Aug	1.22	1.20	1.25	0.03	0.01	0.07	2,247	0.00	0.00	0.00	0	
	15-Aug	1.21	1.19	1.24	0.02	0.00	0.05	1,612	0.00	0.00	0.00	0	
	16-Aug	1.20	1.19	1.24	0.01	0.00	0.05	1,112	0.00	0.00	0.00	0	
	17-Aug	1.20	1.18	1.24	0.01	0.00	0.05	793	0.00	0.00	0.00	0	
	18-Aug	1.19	1.17	1.23	0.00	0.00	0.04	419	0.00	0.00	0.00	0	
	19-Aug	1.18	1.17	1.22	0.00	0.00	0.03	221	0.00	0.00	0.00	0	
	20-Aug	1.18	1.16	1.22	0.00	0.00	0.03	191	0.00	0.00	0.00	0	
	21-Aug	1.17	1.15	1.21	0.00	0.00	0.02	37	0.00	0.00	0.00	0	
	22-Aug	1.17	1.13	1.20	0.00	0.00	0.01	25	0.00	0.00	0.00	0	0.26
	23-Aug	1.20	1.18	1.24	0.01	0.00	0.05	944	0.00	0.00	0.00	0	0.28
	24-Aug	1.19	1.17	1.21	0.00	0.00	0.02	360	0.00	0.00	0.00	7,840,805	0.02
	25-Aug	1.18	1.17	1.22	0.00	0.00	0.03	235					



**Lake Ketchum Hydrologic Data: Oct. 2010 - Oct 2011**

Year	Date	Average of Lake Level Staff Height (feet)	Min of Lake Level Staff Height (feet)	Max of Lake Level Staff Height (feet)	Average of Outlet Total Q (cfs)	Min of Outlet Total Q (cfs)	Max of Outlet Total Q (cfs)	Sum of Outlet Vol (ft3/day)	Average of Inlet Q (cfs)	Min of Inlet Q (cfs)	Max of Inlet Q (cfs)	Sum of Inlet Vol (ft3/day)	Daily Precip Total (inches)
2011	Aug 26-Aug	1.18	1.16	1.22	0.00	0.00	0.03	181					
	27-Aug	1.17	1.15	1.21	0.00	0.00	0.02	102					
	28-Aug	1.16	1.14	1.19	0.00	0.00	0.00	5					
	29-Aug	1.15	1.13	1.19	0.00	0.00	0.00	4					
	30-Aug	1.14	1.12	1.16	0.00	0.00	0.00	0					
	31-Aug	1.12	1.11	1.16	0.00	0.00	0.00	0					
	<b>Aug Total</b>	<b>1.21</b>	<b>1.11</b>	<b>1.33</b>	<b>0.03</b>	<b>0.00</b>	<b>0.22</b>	<b>93,237</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>7,840,828</b>	<b>0.56</b>
	<b>Sep</b>												
	1-Sep	1.11	1.09	1.14	0.00	0.00	0.00	0					
	2-Sep	1.10	1.09	1.15	0.00	0.00	0.00	0					
	3-Sep	1.09	1.07	1.13	0.00	0.00	0.00	0					
	4-Sep	1.08	1.06	1.12	0.00	0.00	0.00	0					
	5-Sep	1.07	1.06	1.10	0.00	0.00	0.00	0					
	6-Sep	1.06	1.04	1.10	0.00	0.00	0.00	0					0.01
	7-Sep	1.05	1.03	1.08	0.00	0.00	0.00	0					
	8-Sep	1.04	1.02	1.06	0.00	0.00	0.00	0					
	9-Sep	1.03	1.01	1.06	0.00	0.00	0.00	0					
	10-Sep	1.03	1.01	1.06	0.00	0.00	0.00	0					
	11-Sep	1.02	1.00	1.05	0.00	0.00	0.00	0					
	12-Sep	1.00	0.99	1.03	0.00	0.00	0.00	0					
	13-Sep	0.99	0.97	1.01	0.00	0.00	0.00	0					
	14-Sep	0.98	0.96	1.00	0.00	0.00	0.00	0					
	15-Sep	0.97	0.95	0.98	0.00	0.00	0.00	0					
	16-Sep	0.96	0.94	0.98	0.00	0.00	0.00	0					
	17-Sep	0.94	0.91	0.97	0.00	0.00	0.00	0					0.04
	18-Sep	0.94	0.91	0.97	0.00	0.00	0.00	0					0.06
	19-Sep	0.94	0.92	0.96	0.00	0.00	0.00	0					
	20-Sep	0.93	0.91	0.94	0.00	0.00	0.00	0					
	21-Sep	0.92	0.89	0.95	0.00	0.00	0.00	0					
	22-Sep	0.95	0.90	0.99	0.00	0.00	0.00	0					0.21
	23-Sep	0.94	0.91	0.99	0.00	0.00	0.00	0					

**Lake Ketchum Hydrologic Data: Oct. 2010 - Oct 2011**

Year	Date	Average of Lake Level Staff Height (feet)	Min of Lake Level Staff Height (feet)	Max of Lake Level Staff Height (feet)	Average of Outlet Total Q (cfs)	Min of Outlet Total Q (cfs)	Max of Outlet Total Q (cfs)	Sum of Outlet Vol (ft3/day)	Average of Inlet Q (cfs)	Min of Inlet Q (cfs)	Max of Inlet Q (cfs)	Sum of Inlet Vol (ft3/day)	Daily Precip Total (inches)
2011	Sep 24-Sep	0.94	0.91	0.97	0.00	0.00	0.00	0					
	25-Sep	0.93	0.86	1.00	0.00	0.00	0.00	0					0.1
	26-Sep	0.94	0.89	1.01	0.00	0.00	0.00	0					0.31
	27-Sep	0.95	0.91	0.97	0.00	0.00	0.00	0					0.14
	28-Sep	0.94	0.92	0.97	0.00	0.00	0.00	0					0.01
	29-Sep	0.93	0.89	0.95	0.00	0.00	0.00	0					
	30-Sep	0.92	0.89	0.95	0.00	0.00	0.00	0					
	<b>Sep Total</b>	<b>0.99</b>	<b>0.86</b>	<b>1.15</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0</b>					<b>0.88</b>
	<b>Oct</b>												
	1-Oct	0.92	0.90	0.93	0.00	0.00	0.00	0					
	2-Oct	0.91	0.88	0.93	0.00	0.00	0.00	0					0.05
	3-Oct	0.91	0.87	0.95	0.00	0.00	0.00	0					0.03
	4-Oct	0.90	0.88	0.93	0.00	0.00	0.00	0					
	5-Oct	0.90	0.89	0.92	0.00	0.00	0.00	0					0.24
	6-Oct	0.91	0.90	0.92	0.00	0.00	0.00	0					0.01
	7-Oct	0.93	0.91	0.95	0.00	0.00	0.00	0					0.29
	8-Oct	0.93	0.91	0.96	0.00	0.00	0.00	0					0.01
	9-Oct	0.92	0.91	0.95	0.00	0.00	0.00	0					
	10-Oct	0.92	0.89	0.96	0.00	0.00	0.00	0					0.04
	11-Oct	0.92	0.88	0.95	0.00	0.00	0.00	0					0.1
	12-Oct	0.92	0.91	0.93	0.00	0.00	0.00	0					
	13-Oct	0.91	0.89	0.94	0.00	0.00	0.00	0					
	14-Oct	0.91	0.90	0.92	0.00	0.00	0.00	0					
	15-Oct	0.90	0.88	0.91	0.00	0.00	0.00	0					
	16-Oct	0.89	0.87	0.91	0.00	0.00	0.00	0					
	17-Oct	0.88	0.87	0.90	0.00	0.00	0.00	0					
	18-Oct	0.88	0.87	0.90	0.00	0.00	0.00	0					
	19-Oct	0.88	0.85	0.89	0.00	0.00	0.00	0					0.07
	20-Oct	0.88	0.88	0.88	0.00	0.00	0.00	0					0.1
	<b>Oct Total</b>	<b>0.91</b>	<b>0.85</b>	<b>0.96</b>	<b>0.00</b>	<b>0.00</b>	<b>0.00</b>	<b>0</b>					<b>1.06</b>
<b>2011 Total</b>		<b>1.40</b>	<b>0.85</b>	<b>1.85</b>	<b>0.79</b>	<b>0.00</b>	<b>5.42</b>	<b>19,901,408</b>	<b>0.32</b>	<b>0.00</b>	<b>4.15</b>	<b>14,382,913</b>	<b>27</b>

## C SEDIMENT RESULTS

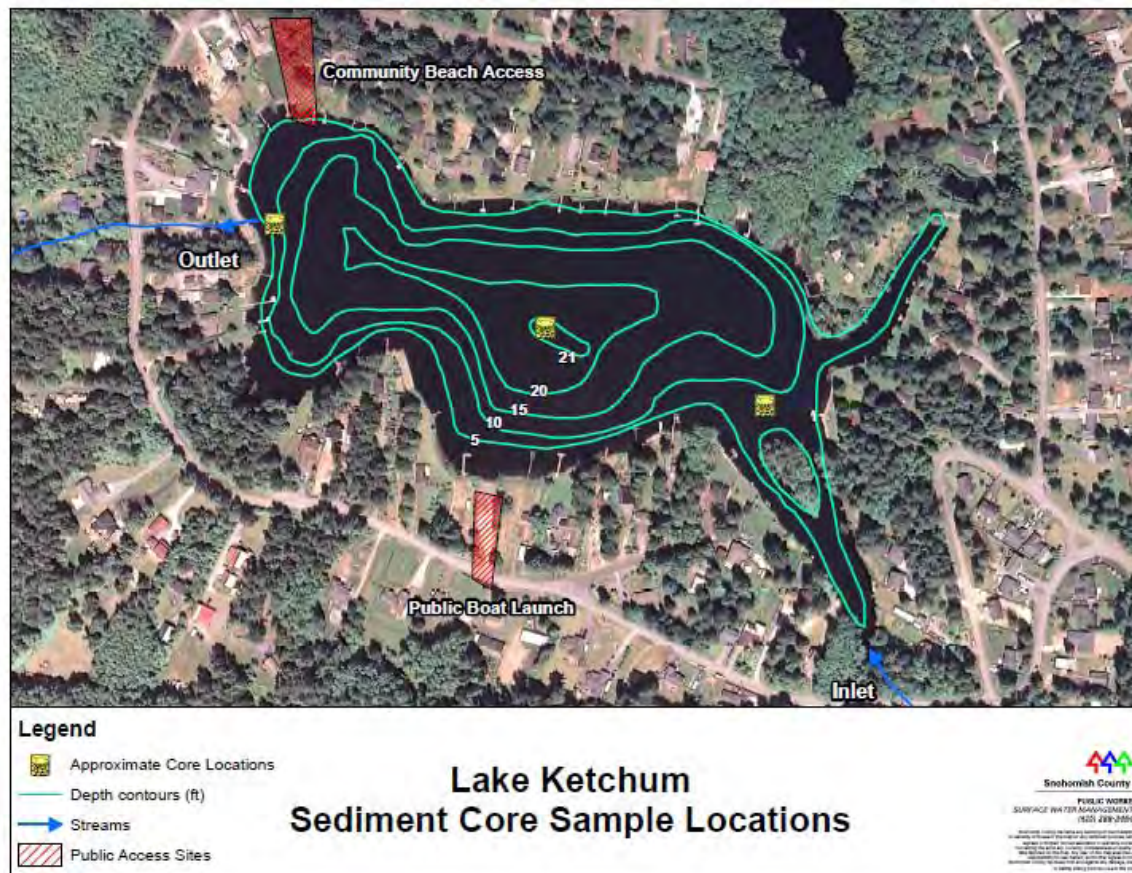
### C.1 SEDIMENT CORE ANALYSIS

A sediment core sample was collected from each of three Lake Ketchum sites (Figure C-1).

- Mid-Deep: Center of the lake in 6 meters (20 feet) of water.
- East Shallow: East end of lake between the island and the south shore in 2 meters (6.6 feet) of water.
- West Shallow: West end of lake near outlet in 4.5 meters (15 feet) of water.

The 40-centimeter cores were sectioned into 5-cm intervals and analyzed for solids and water content and then fractionated into ten constituents. Phosphorus fractions were determined according to procedures in Rydin and Welch (1998). Detailed information on the sediment collection procedures and laboratory analysis can be found in the Quality Assurance Project Plan for Lake Ketchum Sediment Study (Snohomish County, 2011c).

FIGURE C-1: LAKE KETCHUM SEDIMENT CORE SAMPLE LOCATION



The primary purpose of the sediment core analysis was to determine the overall content of phosphorus, the different forms of phosphorus, and the concentrations of analytes to which phosphorus can bind. The information from this analysis helped to determine the appropriate alum dose needed to inactivate phosphorus that could potentially be re-released into the water column and contribute to internal phosphorus loading.

To determine the different sediment fractions a series of sediment digestions were used as outlined in Rydin & Welch (1998). Below is a summary of the different components of sediments that were either analytically determined or calculated.

- Total Phosphorus (TP) – all phosphorus in the sediment prior to any extractions.
- Loosely Bound Phosphorus also known as labile phosphorus which it is determined from an  $\text{NH}_4\text{Cl}$  extraction ( $\text{NH}_4\text{Cl-P}$ ).
- Iron Bound Phosphorus (Fe-P) – the phosphorus fraction that is bound to iron and is derived from an anoxic bicarbonate dithionate digestion (BD-P).
- Aluminum-Bound Phosphorus (Al-P): Derived from an NaOH digestion. Following the digestion the residual is analyzed for reactive phosphorus (NaOH-rp).
- Biogenic Phosphorus – It is also derived from the same NaOH digestion. However, total phosphorus is also performed on the residue and biogenic is this total minus the Al-P. It is also referred to as NaOH-nrP for non-reactive P.
- Calcium-Bound Phosphorus (Ca-P): Derived from an HCl digestion (HCl-P).
- Residual Phosphorus (Residual-P) – It is the remaining phosphorus after the last extraction. It is calculated by taking the total phosphorus and subtracting all of the other fractions.
- Organic Phosphorus (Organic P) – It is the total of the residual phosphorus which is mostly organic or inert phosphorus and the biogenic phosphorus.
- Mobile Phosphorus – mobile phosphorus is the iron bound phosphorus and the loosely bound phosphorus combined. These types of phosphorus can become available during anoxic conditions contributing to internal loading. In the past, the mobile phosphorus concentrations determined the appropriate alum dosing.
- Available Phosphorus – available phosphorus is the mobile phosphorus plus the biogenic phosphorus. In recent years, research has shown that the biogenic phosphorus should also be considered potentially available and should also be used for determining appropriate alum dosages (Reitzel et al., 2005).

## C.2 SEDIMENT CORE RESULTS

Figure C-2: Tables of Lake Ketchum Sediment Core Analysis Results

SAMPLE ID	% SOLIDS	% WATER	VSS (%)	TOTAL-P (mg/kg)	LOOSELY BOUND P	FE BOUND P	AL BOUND P	BIOGENIC P (mg/kg)
					(NH4CL) (mg/kg)	(DITHIONATE) (mg/kg)	(NAOH) (mg/kg)	
MID2 0-5	4.41%	95.6%	37.0%	2202	2.00	169	1097	608
MID2 5-10	5.49%	94.5%	42.8%	1408	2.00	215	431	613
MID2 10-15	6.32%	93.7%	40.7%	1051	2.00	140	380	404
MID2 15-20	7.22%	92.8%	43.9%	807	2.00	41.6	302	350
MID2 20-25	7.28%	92.7%	39.0%	808	2.00	125	298	291
MID2 25-30	7.09%	92.9%	40.7%	850	19.4	123	277	320
MID2 30-40	7.75%	92.3%	38.3%	889	17.4	116	319	290
INLET1 0-5	5.34%	94.7%	58.3%	914	2.00	49.7	247	477
INLET1 5-10	5.30%	94.7%	50.2%	1012	2.00	111	232	504
INLET1 10-15	6.23%	93.8%	45.0%	964	2.00	89.9	251	462
INLET1 15-20	5.90%	94.1%	58.9%	690	2.00	100	171	324
INLET1 20-25	6.41%	93.6%	76.1%	603	2.00	88.0	107	336
INLET1 25-30	6.22%	93.8%	75.0%	447	2.00	27.3	119	260
INLET1 30-40	7.09%	92.9%	73.3%	646	2.00	93.7	155	334
OUTLET1 0-5	5.60%	94.4%	52.5%	843	2.00	58.1	247	367
OUTLET1 5-10	6.55%	93.5%	49.5%	702	2.00	56.6	243	284
OUTLET1 10-15	7.78%	92.2%	49.0%	719	2.00	54.4	214	337
OUTLET1 15-20	8.83%	91.2%	53.7%	679	2.00	44.8	218	321
OUTLET1 20-25	9.02%	91.0%	45.6%	691	2.00	45.5	221	326
OUTLET1 25-30	9.12%	90.9%	46.7%	627	2.00	44.7	190	309

SAMPLE ID	CA BOUND P (HCL)	ORGANIC P (mg/kg)	ALUMINUM (mg/kg)	CALCIUM (mg/kg)	IRON (mg/kg)	Mobile-P (mg/kg)	Available P (mg/kg)
	(mg/kg)						
MID2 0-5	115	822	13742	9638	20860	171	779
MID2 5-10	53.7	709	8850	8078	10565	217	830
MID2 10-15	34.9	496	5128	6099	5749	142	546
MID2 15-20	36.1	427	3800	5418	5313	44	394
MID2 20-25	21.6	364	3323	4842	4230	127	418
MID2 25-30	37.3	393	3419	4779	3802	143	463
MID2 30-40	77.4	359	3904	4826	3504	133	424
INLET1 0-5	38.9	578	7002	11300	11768	52	529
INLET1 5-10	41.5	627	8440	12944	14823	113	617
INLET1 10-15	43.6	579	7162	11249	12964	92	554
INLET1 15-20	27.0	392	4296	8851	5950	102	426
INLET1 20-25	28.4	380	4151	9770	3397	90	426
INLET1 25-30	11.5	289	2944	6394	1631	29	289
INLET1 30-40	19.4	378	3398	5463	1383	96	429
OUTLET1 0-5	39.0	498	7576	8714	8605	60	427
OUTLET1 5-10	26.5	375	4734	5778	4187	59	343
OUTLET1 10-15	26.8	424	3879	5321	3407	56	393
OUTLET1 15-20	22.6	393	4450	5467	2960	47	368
OUTLET1 20-25	25.5	399	4838	5256	3071	47	374
OUTLET1 25-30	20.1	373	4151	4825	3110	47	356
OUTLET1 30-40	12.7	322	3975	4640	2535	50	310

The sediment findings and graphs for total phosphorus and available phosphorus are presented in the algae control plan. Additional graphs of iron-bound phosphorus and aluminum-bound phosphorus in comparison to other nutrient rich lakes are included below (Figure C-3 and Figure C-4).

Total iron to total phosphorus (TFe:TP) ratios were lower at the deep and outlet sites in the top 15 cm of sediment (Table 1). All ratios are less than 15:1, below which Fe was found to be insufficient to fully control sediment P (Jensen et al., 1992). That indicates some of the sediment TP can be recycled even under aerobic conditions.

FIGURE C-3: LAKE KETCHUM IRON-BOUND PHOSPHORUS COMPARED TO OTHER ENRICHED LAKES

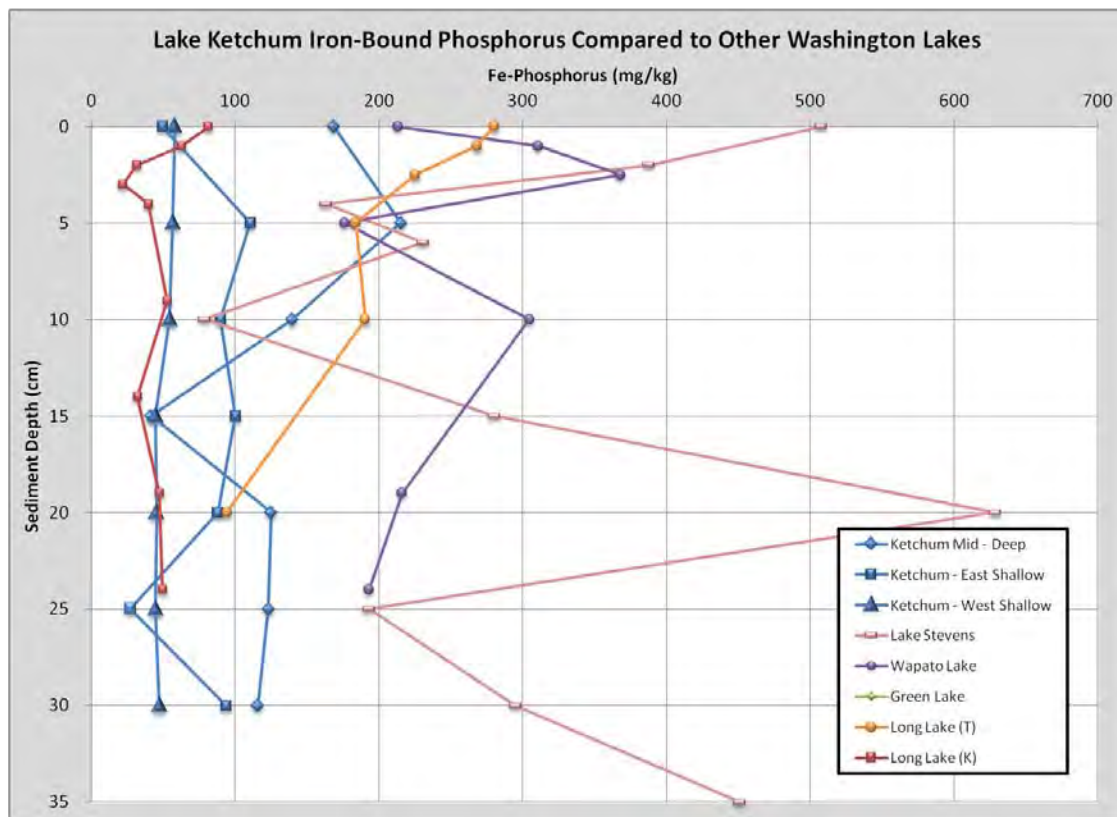
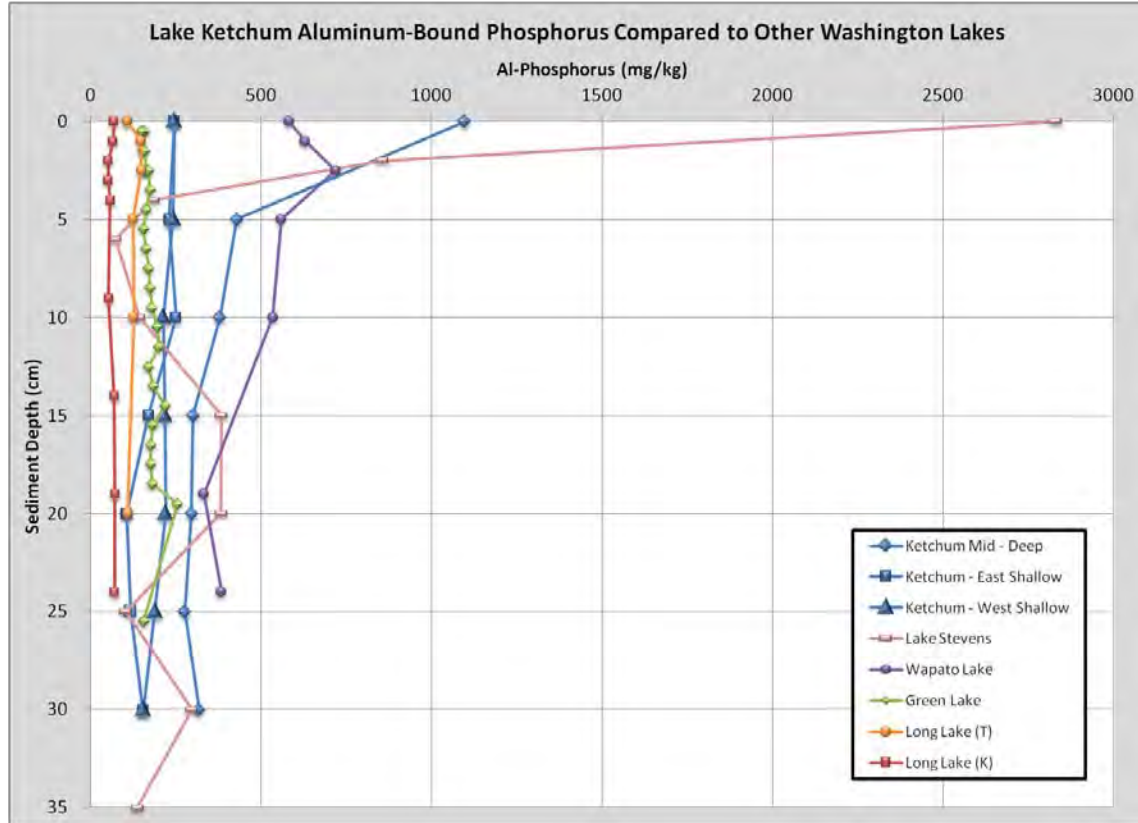


FIGURE C-4: LAKE KETCHUM ALUMINUM-BOUND PHOSPHORUS COMPARED TO OTHER ENRICHED LAKES



### C.3 SEDIMENT DATA LAB REPORTS & CHAIN OF CUSTODY

The sediment sample chain of custodies and laboratory reports including quality assurance results of the analysis are provided below.





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<b>CASE FILE NUMBER:</b>	<b>TET007-67A</b>	<b>PAGE</b>	<b>1</b>
<b>REPORT DATE:</b>	<b>10/31/11</b>		
<b>DATE SAMPLED:</b>	<b>09/13/11</b>	<b>DATE RECEIVED:</b>	<b>09/13/11</b>
<b>FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON SEDIMENT SAMPLES TETRA TECH</b>			

**CASE NARRATIVE**

Three sediment cores were received by the laboratory in good condition. Each core was sectioned into seven different samples and analyzed according to the chain of custody. Phosphorus fractions were determined according to the method of Rydin and Welch. Successive extractions with  $\text{NH}_4\text{Cl}$ , Bicarbonate/Dithionate,  $\text{NaOH}$ , and  $\text{HCl}$  were performed and analyzed for phosphorus. One part of Organic P was determined by digesting the residue after the inorganic fractions were extracted. Organic P includes the P after the inorganic fractions plus Biogenic P. Total P is the sum of all fractions minus Biogenic P, which is part of the Organic P fraction. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows, while QA/QC data is contained on subsequent pages.

**SAMPLE DATA - SEDIMENTS (DRY WT. BASIS)**

SAMPLE ID	% SOLIDS	% WATER	VSS (%)	TOTAL-P (mg/kg)	LOOSELY BOUND P (NH <sub>4</sub> CL) (mg/kg)	FE BOUND P (DITHIONATE) (mg/kg)	AL BOUND P (NAOH) (mg/kg)	BIOGENIC P (mg/kg)	CA BOUND P (HCL) (mg/kg)	ORGANIC P (mg/kg)
MID2 0-5	4.41%	95.6%	37.0%	2202	<2.00	169	1097	608	115	822
MID2 5-10	5.49%	94.5%	42.8%	1408	<2.00	215	431	613	53.7	709
MID2 10-15	6.32%	93.7%	40.7%	1051	<2.00	140	380	404	34.9	496
MID2 15-20	7.22%	92.8%	43.9%	807	<2.00	41.6	302	350	36.1	427
MID2 20-25	7.28%	92.7%	39.0%	808	<2.00	125	298	291	21.6	364
MID2 25-30	7.09%	92.9%	40.7%	850	19.4	123	277	320	37.3	393
MID2 30-40	7.75%	92.3%	38.3%	889	17.4	116	319	290	77.4	359
INLET1 0-5	5.34%	94.7%	58.3%	914	<2.00	49.7	247	477	38.9	578
INLET1 5-10	5.30%	94.7%	50.2%	1012	<2.00	111	232	504	41.5	627
INLET1 10-15	6.23%	93.8%	45.0%	964	<2.00	89.9	251	462	43.6	579
INLET1 15-20	5.90%	94.1%	58.9%	690	<2.00	100	171	324	27.0	392
INLET1 20-25	6.41%	93.6%	76.1%	603	<2.00	88.0	107	336	28.4	380
INLET1 25-30	6.22%	93.8%	75.0%	447	<2.00	27.3	119	260	11.5	289
INLET1 30-40	7.09%	92.9%	73.3%	646	<2.00	93.7	155	334	19.4	378
OUTLET1 0-5	5.60%	94.4%	52.5%	843	<2.00	58.1	247	367	39.0	498
OUTLET1 5-10	6.55%	93.5%	49.5%	702	<2.00	56.6	243	284	26.5	375
OUTLET1 10-15	7.78%	92.2%	49.0%	719	<2.00	54.4	214	337	26.8	424
OUTLET1 15-20	8.83%	91.2%	53.7%	679	<2.00	44.8	218	321	22.6	393
OUTLET1 20-25	9.02%	91.0%	45.6%	691	<2.00	45.5	221	326	25.5	399
OUTLET1 25-30	9.12%	90.9%	46.7%	627	<2.00	44.7	190	309	20.1	373
OUTLET1 30-40	9.23%	90.8%	43.7%	538	<2.00	47.6	156	260	12.7	322





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<b>CASE FILE NUMBER:</b>	<b>TET007-67A</b>	<b>PAGE</b>	<b>2</b>
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<b>FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON SEDIMENT SAMPLES TETRA TECH</b>			

## QA/QC DATA- SEDIMENTS

QC PARAMETER	% SOLIDS	VSS	TOTAL-P	LOOSELY BOUND P (NH <sub>4</sub> CL)	FE BOUND P (DITHIONATE)	AL BOUND P (NAOH)	BIOGENIC P	CA BOUND P (HCL)	ORGANIC P
	(%)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
METHOD	SM18 2540B	SM18 2540D	CALCULATED	SM18 4500PF	SM18 4500PF	SM18 4500PF	EPA 365.1	SM18 4500PF	EPA 365.1
DATE PREPARED	10/12/11	10/12/11	10/17/11	10/14/11	10/14/11	10/14/11	10/17/11	10/14/11	10/17/11
DATE ANALYZED	1.00%	0.01	5.00	2.00	2.00	2.00	2.00	2.00	2.00
DETECTION LIMIT									
DUPLICATE									
SAMPLE ID	OUTLET1 30-40	OUTLET1 30-40	OUTLET1 30-40	OUTLET1 30-40	OUTLET1 30-40	OUTLET1 30-40	OUTLET1 30-40	OUTLET1 30-40	OUTLET1 30-40
ORIGINAL	9.23%	43.7%	538	<2.00	47.6	156	260	12.7	322
DUPLICATE	9.19%	44.1%	579	<2.00	39.2	169	289	14.8	356
RPD	0.40%	0.71%	7.45%	NC	19.35%	8.05%	10.25%	15.18%	10.27%
SPIKE SAMPLE									
SAMPLE ID									
ORIGINAL									
SPIKED SAMPLE									
SPIKE ADDED	NA	NA	NA	NA	NA	NA	NA	NA	NA
% RECOVERY									
QC CHECK (mg/l)									
FOUND				0.032	0.032	0.032	0.089	0.032	0.089
TRUE				0.033	0.033	0.033	0.090	0.033	0.090
% RECOVERY	NA		NA	98.73%	98.73%	98.73%	98.59%	98.73%	98.59%
BLANK	NA	NA	NA	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00

RPD = RELATIVE PERCENT DIFFERENCE  
 NA = NOT APPLICABLE OR NOT AVAILABLE  
 NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.  
 OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION

SUBMITTED BY:

STEVEN LAZOFF  
 LABORATORY DIRECTOR



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<b>CASE FILE NUMBER:</b>	<b>TET007-67B</b>	<b>PAGE</b>	<b>1</b>
<b>REPORT DATE:</b>	<b>10/31/11</b>		
<b>DATE SAMPLED:</b>	<b>09/13/11</b>	<b>DATE RECEIVED:</b>	<b>09/13/11</b>
<b>FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON SEDIMENT SAMPLES TETRA TECH</b>			

**CASE NARRATIVE**

Three sediment cores were received by the laboratory in good condition. Each core was sectioned into seven different samples and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows, while QA/QC data is contained on subsequent pages.

**SAMPLE DATA - SEDIMENTS (DRY WT. BASIS)**

SAMPLE ID	% SOLIDS	% WATER	ALUMINUM (mg/kg)	CALCIUM (mg/kg)	IRON (mg/kg)
MID2 0-5	4.41%	95.6%	13742	9638	20860
MID2 5-10	5.49%	94.5%	8850	8078	10565
MID2 10-15	6.32%	93.7%	5128	6099	5749
MID2 15-20	7.22%	92.8%	3800	5418	5313
MID2 20-25	7.28%	92.7%	3323	4842	4230
MID2 25-30	7.09%	92.9%	3419	4779	3802
MID2 30-40	7.75%	92.3%	3904	4826	3504
INLET1 0-5	5.34%	94.7%	7002	11300	11768
INLET1 5-10	5.30%	94.7%	8440	12944	14823
INLET1 10-15	6.23%	93.8%	7162	11249	12964
INLET1 15-20	5.90%	94.1%	4296	8851	5950
INLET1 20-25	6.41%	93.6%	4151	9770	3397
INLET1 25-30	6.22%	93.8%	2944	6394	1631
INLET1 30-40	7.09%	92.9%	3398	5463	1383
OUTLET1 0-5	5.60%	94.4%	7576	8714	8605
OUTLET1 5-10	6.55%	93.5%	4734	5778	4187
OUTLET1 10-15	7.78%	92.2%	3879	5321	3407
OUTLET1 15-20	8.83%	91.2%	4450	5467	2960
OUTLET1 20-25	9.02%	91.0%	4838	5256	3071
OUTLET1 25-30	9.12%	90.9%	4151	4825	3110
OUTLET1 30-40	9.23%	90.8%	3975	4640	2535



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<b>CASE FILE NUMBER:</b>	<b>TET007-67B</b>	<b>PAGE</b>	<b>2</b>
<b>REPORT DATE:</b>	<b>10/31/11</b>		
<b>DATE SAMPLED:</b>	<b>09/13/11</b>	<b>DATE RECEIVED:</b>	<b>09/13/11</b>
<b>FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON SEDIMENT SAMPLES TETRA TECH</b>			

## QA/QC DATA- SEDIMENTS

QC PARAMETER	% SOLIDS	ALUMINUM (mg/kg)	CALCIUM (mg/kg)	IRON (mg/kg)
METHOD	SM18 2540B	EPA 6010	EPA 6010	EPA 6010
DATE ANALYZED	10/12/11	10/19/11	10/29/11	10/19/11
DETECTION LIMIT	1.00%	3.00	10.0	2.00
DUPLICATE				
SAMPLE ID	OUTLET1 30-40	INLET1 30-40	INLET1 30-40	INLET1 30-40
ORIGINAL	9.23%	3398	5463	1383
DUPLICATE	9.19%	3567	5482	1236
RPD	0.40%	4.86%	0.35%	11.26%
SPIKE SAMPLE				
SAMPLE ID		INLET1 30-40	INLET1 30-40	INLET1 30-40
ORIGINAL		3398	5463	1383
SPIKED SAMPLE		4883	22476	2593
SPIKE ADDED		1410	14102	1410
% RECOVERY	NA	105.29%	120.65%	85.77%
QC CHECK (mg/l)				
FOUND		1.04	10.3	9.77
TRUE		1.00	10.0	10.0
% RECOVERY	NA	104.05%	102.73%	97.65%
BLANK	NA	<3.00	<10.0	<2.00

RPD = RELATIVE PERCENT DIFFERENCE  
 NA = NOT APPLICABLE OR NOT AVAILABLE  
 NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT  
 OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION

SUBMITTED BY:

STEVEN LAZOFF  
 LABORATORY DIRECTOR



**3927 Aurora Ave. N / Seattle, WA 98103 / (206) 632-2715**

CLIENT: TETRA TECH  
SAMPLING DATE: 09/13/11  
SAMPLERS: \_\_\_\_\_

SHEET 1 OF 4  
PROJECT ID: LAKE KETCHUM  
CASE FILE NO.: \_\_\_\_\_  
DATA RECORDED BY: \_\_\_\_\_

## PARAMETERS

[illegible]

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name			DAVIDEN GADOMSKY	09/13/11
Signature			<i>[Signature]</i>	
Affiliation			ARJ	

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name				
Signature				
Affiliation				

**Miscellaneous Notes (Hazardous Materials, Quick turn-around time, etc.):**



**3927 Aurora Ave. N / Seattle, WA 98103 / (206) 632-2715**

SHEET 2 OF 4

PROJECT ID: \_\_\_\_\_

**CASE FILE NO.:** \_\_\_\_\_

DATA RECORDED BY:

## PARAMETERS

[illegible]

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name				
Signature				
Affiliation				

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name				
Signature				
Affiliation				

Miscellaneous Notes (Hazardous Materials, Quick turn-around time, etc.): \_\_\_\_\_



**Aquatic Research Incorporated**

**3927 Aurora Ave. N / Seattle, WA 98103 / (206) 632-2715**

## CHAIN-OF-CUSTODY RECORD

CLIENT: TETRATECH

SAMPLING DATE: 09/13/11

**SAMPLERS:**

SHEET 3 OF 4

**PROJECT ID:**

**CASE FILE NO.:**

DATA RECORDED BY:

## SAMPLE INFORMATION

[illegible]

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name				
Signature				
Affiliation				

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name				
Signature				
Affiliation				

**Miscellaneous Notes (Hazardous Materials, Quick turn-around time, etc.):**

## CHAIN-OF-CUSTODY RECORD

CLIENT: Tetra Tech - Harry Gibbons  
SAMPLING DATE: 7/13/11  
SAMPLERS: \_\_\_\_\_

SHEET 4 OF 4  
PROJECT ID: \_\_\_\_\_  
CASE FILE NO.: \_\_\_\_\_  
DATA RECORDED BY: \_\_\_\_\_

## SAMPLE INFORMATION

Lake Ketchikan

## PARAMETERS

SAMPLE ID	DATE/TIME COLLECTED	B O T T #	NOTES
MID #1 Dup			
MID #2			
Section 0-5, 5-10, 10-15, 15-20, 20-25, 25-30, 30-40 cm			
Inlet #1			
Outlet #1			
see p. 24			

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name				
Signature				
Affiliation				

	Relinquished By	Date/Time	Received By	Date/Time
Printed Name				
Signature				
Affiliation				

Miscellaneous Notes (Hazardous Materials, Quick turn-around time, etc.):

## D WATER BUDGET

A water budget was created for Lake Ketchum that accounted for all of the water inflows and outflows for the time period 10/12/2010 to 10/24/2011. The budget is based on a two-week time step. The time period includes 54 weeks instead of 52 because detailed data were available and a longer period helps in modeling movements of phosphorus within the lake.

Lake Ketchum has a surface area of approximately 25.5 acres with an average depth of 12 feet and a maximum depth of 21 feet. The estimated lake storage is 296 acre feet. Using bathymetry data (Sumioka & Dion, 1985) and a 2009 aerial photograph, the surface area for each lake depth was determined. The lake volume was calculated from the surface areas (figure d 1). The volume stage relationship was developed and used to calculate the lake volume at each time step based on the lake level

The primary sources of water flowing into Lake Ketchum include: 1) precipitation, 2) flow from the primary stream flowing into the lake from the southeast corner which originates at the former dairy farm, 3) surface runoff from the remainder of the watershed, and 4) groundwater (GW) inputs. The outflows of water from the lake include: 1) outlet flow – flow from the outlet located on the western side of the lake, 2) evaporation and 3) groundwater (GW) losses.

### Lake Ketchum Water Budget Model

$$\Delta \text{ Lake Volume} = \underbrace{[Precip + Inlet + Runoff + GW_{gain}]}_{\text{Inflows}} - \underbrace{[Evap + Outlet + GW_{loss}]}_{\text{Outflows}}$$

### D.1 STAGE-STORAGE RATING CURVE

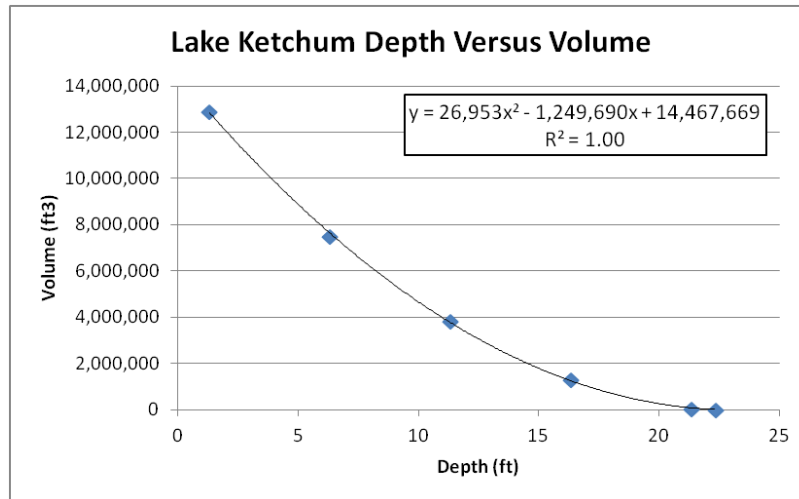
Lake Ketchum has a surface area of approximately 25.5 acres with an average depth of 12 feet and a maximum depth of 21 feet. The estimated lake storage is 296 acre feet. Using bathymetry data (Sumioka & Dion, 1985) and a 2009 aerial photograph, the surface area for each lake depth was determined. The lake volume was calculated from the surface areas (Figure D-1). The volume stage relationship was developed and used to calculate the lake volume at each time step based on the lake level (Figure D-2).

FIGURE D-1: LAKE KETCHUM STAGE AREA STORAGE TABLE

Depth (m)	Surface Area (m <sup>2</sup> )	Volume (m <sup>3</sup> )
0	102,869	363,671
1	88,412	262,481
2	73,801	177,726
3	59,036	109,406
4	44,116	57,520
5	29,043	22,068
6	13,814	3,050
6.4	0	0



FIGURE D-2: LAKE KETCHUM DEPTH VOLUME RELATIONSHIP



## D.2 OBSERVED OR ESTIMATED PARAMETERS

The following parameters were either measured during the course of 2010-2011 or estimated from existing climate data:

*Change in Lake Volume ( $\Delta V$ ):* Continuous lake level measurements were obtained through the use of an absolute pressure transducer coupled with a data logger. The transducer recorded lake levels every 15 minutes throughout the year. The lake level readings were converted to lake volumes based on the stage-storage rating curve. A staff height of 1.34 was used as the starting point for the water year (October 2010) and for the size of the normal lake surface (25.5 acres).

*Precipitation:* A rain gage was installed on the northeast finger of the lake on private property located off of 78<sup>th</sup> Dr. NW. The gage recorded every 0.01 inch of precipitation that occurred throughout the year. The first two weeks of rain data prior to the installation of the precipitation gage were obtained from a neighboring Snohomish County rain gage. The precipitation was multiplied by a constant lake surface area of 97,128 m<sup>2</sup> or 24 acres (this was the size of the lake used in the 1997 study and slightly underestimates the actual precipitation).

*Inlet stream flow:* A small wooden dam with a holding pool and a 63° V-notch weir was installed on the main inlet stream on the southeast shore of the lake. Continuous water level measurements were taken in the weir holding pool. The inlet flow was derived from the weir water level measurements as described above in Section B.1. Another very small inlet #2 near the public boat launch was also identified in the 1997 study. Tetra Tech incorporated this inlet into the model as a separate inflow. The contribution was held at 1% based on the Entranco study. However, since it accounted for only 1% of all inflows, it was combined with surface runoff from the remainder of the watershed.

---

*Outlet Flow:* Outlet flow was calculated based on the continuous lake level measurements taken and the geometry of the weir box located at the outlet. A full description of these calculations can be found above in Section B.1.2.

*Evaporation:* Evaporation was estimated based on monthly pan evaporation data from the Seattle Maple Leaf Station obtained from the Western Regional Climate Center. The evaporation values were multiplied by a constant lake surface area of 97,128 m<sup>2</sup> or 24 acres (this was the size of the lake used in the 1997 study and slightly underestimates the actual evaporation).

### D.3 MODELED PARAMETERS

---

An initial water budget was developed using the known parameters. The remaining unmeasured components of inflow included shallow groundwater contributions and surface runoff from the remainder of the watershed. To account for the unmeasured inflows, the shallow groundwater losses were estimated based upon a hydrogeologic evaluation performed in 1996 by Entranco (1997). From this study, a constant groundwater outflow of 80 m<sup>3</sup> per two weeks or 5.7 m<sup>3</sup>/day was applied for the entire water year. However, a constant groundwater outflow caused the “remaining watershed inflow” to be negative during dry periods of the year, which is not possible. Thus, it was determined that the lake was actually losing more water via groundwater outflow during certain times than the 5.7 m<sup>3</sup>/day. In order to balance the water budget, the amount of groundwater outflow needed to offset the negative “remaining watershed” inflow was determined for each time step during the dry period (June 7th – October 25th). Increasing the estimated groundwater outflow during this period resulted in a balanced water budget (Figure D-3) so that the relative contributions of surface water runoff and shallow groundwater could be estimated.

For the study period, the total inflows from groundwater and surface runoff (not including the main inlet) amounted to 58% of the inflows. This was similar to the findings in the 1997 study, which found that 59% of the inflow came from these sources. The groundwater inflow was estimated to be 33% of this amount for each time period based upon the Entranco hydrogeologic evaluation (Entranco, 1997). The remaining flow, accounting for 25% of the annual inflow, was considered surface water runoff from the remainder of the watershed.

FIGURE D-3: LAKE KETCHUM WATER BUDGET

LAKE KETCHUM WATER BUDGET

*Description:* Water Budget based on a twice monthly timestep, Solved for Unknown Inflows (GW and Remaining Basin Interflow)  
Inlet + Precipitation + GW + Remaining Basin - Outflow - Evaporation - GW = Change in Lake Storage

$$y = 26,953.69x^2 - 1,249,690.33x + 14,467,669.02$$
$$R^2 = 1.00$$

Water Year	Bi-Week Number	Date Range		Inflows						Outflows				Internal Volume					Balance
		From	To	Precipitation Depth (m)	Direct Precipitation V (m³)	Inlet Inflow V (m³)	Groundwater Inflow (m3)	Inlet #2 Inflow (m3)	Other Inflows (m3)	Potential Evapotranspiration (m)	Surface Evaporation V (m³)	Groundwater Outflow (m³)	Outlet V (m³)	Staff Height at Timestep (ft)	Adjusted Staff Hieght for Volume Equation (ft)	Volume at Timestep (ft³)	Volume at Timestep (m³)	Change in Storage per Timestep (m³)	
WY 2011	1	10/12/2010	10/25/2010	0.0254	2,467	204	-1,031	-31	-756	0.0186	1,805	200	150	1.34	1.34	12,841,482	363,671	-1,302	0
	2	10/26/2010	11/8/2010	0.0701	6,809	1,253	2,218	67	1,627	0.0130	1,192	80	4,339	1.53	1.15	13,066,171	370,034	6,363	0
	3	11/9/2010	11/22/2010	0.0503	4,885	5,181	10,136	307	7,438	0.0088	852	80	27,352	1.52	1.16	13,054,297	369,698	-336	0
	4	11/23/2010	12/6/2010	0.0198	1,924	5,630	6,019	182	4,417	0.0076	721	80	20,726	1.42	1.26	12,935,851	366,343	-3,354	0
	5	12/7/2010	12/20/2010	0.0617	5,995	13,152	4,245	129	3,115	0.0061	591	80	24,960	1.45	1.23	12,971,328	367,348	1,005	0
	6	12/21/2010	1/3/2011	0.0091	888	6,078	5,223	158	3,833	0.0063	616	80	17,158	1.40	1.28	12,912,226	365,674	-1,674	0
	7	1/4/2011	1/17/2011	0.1064	10,337	22,184	12,402	376	9,101	0.0070	680	80	41,505	1.76	0.92	13,340,768	377,811	12,136	0
	8	1/18/2011	1/31/2011	0.0564	5,477	28,126	14,533	440	10,664	0.0070	703	80	65,898	1.54	1.14	13,078,051	370,370	-7,440	0
	9	2/1/2011	2/14/2011	0.0259	2,516	13,096	7,185	218	5,273	0.0104	1,011	80	29,548	1.47	1.21	12,995,007	368,019	-2,352	0
	10	2/15/2011	2/28/2011	0.0526	5,107	13,506	8,882	269	6,518	0.0104	1,082	80	28,746	1.60	1.08	13,149,442	372,392	4,374	0
	11	3/1/2011	3/14/2011	0.0485	4,712	19,167	16,932	513	12,425	0.0206	2,005	80	52,001	1.59	1.09	13,137,530	372,055	-337	0
	12	3/15/2011	3/28/2011	0.0442	4,293	17,921	19,334	586	14,188	0.0206	2,005	80	54,911	1.57	1.11	13,113,722	371,381	-674	0
	13	3/29/2011	4/11/2011	0.0927	9,005	25,949	22,760	690	16,702	0.0348	3,504	80	69,835	1.62	1.06	13,173,282	373,067	1,687	0
	14	4/12/2011	4/25/2011	0.0277	2,689	11,140	16,409	497	12,041	0.0386	3,753	80	40,293	1.58	1.10	13,125,624	371,718	-1,350	0
	15	4/26/2011	5/9/2011	0.0495	4,811	10,499	13,383	406	9,821	0.0480	4,765	80	34,749	1.56	1.12	13,101,827	371,044	-674	0
	16	5/10/2011	5/23/2011	0.0521	5,057	14,629	21,743	659	15,956	0.0532	5,170	80	54,141	1.52	1.16	13,054,297	369,698	-1,346	0
	17	5/24/2011	6/6/2011	0.0163	1,579	5,056	19,531	592	14,333	0.0564	5,532	80	34,806	1.54	1.14	13,078,051	370,370	673	0
	18	6/7/2011	6/20/2011	0.0165	1,604	1,959	12,356	374	9,067	0.0607	5,895	100	22,388	1.45	1.23	12,971,328	367,348	-3,022	0
	19	6/21/2011	7/4/2011	0.0086	839	734	9,119	276	6,691	0.0653	6,455	100	13,446	1.38	1.30	12,888,623	365,006	-2,342	0
	20	7/5/2011	7/18/2011	0.0165	1,604	339	7,746	235	5,684	0.0769	7,465	100	9,377	1.34	1.34	12,841,482	363,671	-1,335	0
	21	7/19/2011	8/1/2011	0.0079	765	127	6,329	192	4,644	0.0756	7,224	250	6,580	1.28	1.40	12,770,932	361,673	-1,998	0
	22	8/2/2011	8/15/2011	0.0000	0	0	3,864	117	2,836	0.0595	5,782	500	2,195	1.23	1.45	12,712,288	360,012	-1,661	0
	23	8/16/2011	8/29/2011	0.0142	1,382	0	1,163	35	854	0.0595	5,782	500	131	1.14	1.54	12,607,069	357,032	-2,980	0
	24	8/30/2011	9/12/2011	0.0003	25	0	5	0	4	0.0440	4,144	500	0	1.00	1.68	12,444,263	352,422	-4,611	0
	25	9/13/2011	9/26/2011	0.0183	1,776	0	254	8	186	0.0414	4,018	500	0	0.93	1.75	12,363,257	350,127	-2,294	0
	26	9/27/2011	10/10/2011	0.0208	2,023	0	43	1	31	0.0251	2,279	800	0	0.90	1.78	12,328,620	349,147	-981	0
WY 2012	27	10/11/2011	10/24/2011	0.0099	962	0.0000	462.6191	14.0188	339.4808	0.0186	1,805	300	0	0.89	1.79	12,317,086	348,820	-327	0
Annual Totals				0.92	89,529	215,931	241,247	7,311	177,032	0.89	86,839	5,130	655,234	---		---		-16,153	0
					12.25%	29.54%	33.00%	1.00%	24.22%										

Total Annual Inflow 731,050 m³

From Entranco Report  
GW Annual Inflow 33%  
Inlet #2 1% annual inflow  
Other inflows 18%

Total Annual Inflow 747,203 m³

\* For first time step change in storage calculation; use staff height on 10/12 of 1.379 to calculate lake volume prior to time step #1

## E LAKE KETCHUM PHOSPHORUS BUDGET

A phosphorus budget was created using the observed data in Lake Ketchum that accounted for all of the phosphorus inflows and outflows to the lake during the study period. The phosphorus budget was based on the water budget and therefore also uses a two-week time step extending from 10/12/2010 to 10/24/2011. All inflows of phosphorus to the lake minus all outflows of phosphorus from the lake should equal the change in phosphorus concentration over the year.

$$\Delta[TP] = TP_{Inputs} - TP_{Outputs}$$

Or

$$\Delta[P] = \underbrace{[P_{precip} + P_{inlet} + P_{runoff} + P_{GW\ gain} + P_{internal}]}_{Inflows} - \underbrace{[P_{outlet} + P_{GW\ loss} + P_{Sedimentation}]}_{Outflows}$$

### E.1 PHOSPHORUS INFLOWS

*Precipitation:* Phosphorus concentrations in precipitation to Lake Ketchum were assumed to be a constant 20 µg/l based on measurements taken at Lake Sammamish in the 1970s (Welch, E.B., unpublished data).

*Inlet flow:* Total phosphorus (TP) concentrations were measured in the lake inlet on a bimonthly basis throughout the study period. Concentrations for time periods between sampling events were interpolated from the preceding and following weeks.

*Surface Runoff:* A constant TP concentration of 70 µg/L was used for the for unmonitored “remaining basin” runoff. The concentration was based on data that Entranco (1997) estimated for surface runoff phosphorus (P) concentrations from Forest, Grass, Wetland, and Normal Impervious land uses. Initially, the TP concentration of 54 µg/l was considered from a comparable lake located in King County, WA. However, the lower value was insufficient to calibrate the model during the winter period. The 70 µg/l estimate is reasonable given that 51% of the Lake Ketchum watershed was developed in roads and housing and only 19% was forested (Entranco, 1997). In comparison, the average TP from the completely developed west side of the Lake Sammamish watershed was 109 µg/l (Welch et al., 1980).

*Groundwater inputs:* The same TP concentration of 70 µg/l used for the surface runoff was also used to estimate shallow groundwater inputs.

*Internal Loading:* Internal loading stems from the release of P from sediments to the water column. It is also referred to as sediment release. Internal loading could not be directly measured during the study year and was solved for as an unknown parameter.

## E.2 PHOSPHORUS OUTFLOWS

*Outlet flow:* The TP concentrations in the outlet flow were based on the 1-meter TP concentrations taken during monthly or semi-monthly lake sampling. Concentrations for time periods between sampling events were interpolated from the preceding and following weeks.

*Groundwater losses:* The TP concentrations for groundwater losses were based on the 1 meter soluble reactive phosphorus concentrations taken during semi-monthly lake sampling. Concentrations for time periods between sampling events were interpolated from the preceding and following weeks.

*Sedimentation:* Settling or sedimentation is the movement of P through the water column to eventually settle on the lake bottom. It is also referred to as burial. Sedimentation could not be directly measured during the study year and was solved for as an unknown parameter.

## E.3 INTERNAL LOAD AND SEDIMENTATION

For Lake Ketchum, the internal phosphorus loading and the phosphorus sedimentation were unknown. Therefore, the unknown terms were solved for and a residual obtained. If the residual was positive for a two-week period, net internal loading was assumed to be occurring. If the residual was negative, net sedimentation was assumed to be occurring.

$$Net\ P_{Internal\ or\ Sedimentation} = \underbrace{[P_{prec} + P_{inlet} + P_{runoff} + P_{GW\ gain}]}_{Inflows} - \underbrace{[P_{outlet} + P_{GW\ loss} + \Delta P_{inlake}]}_{Outflows}$$

Net internal P loading was positive during the stratified, anoxic period from April-October, except during four time steps (Figure E-1). Net internal load was calculated as the sum of all positive values from 4/12/2011 (when stratification started) through 9/26/2011 (before entrainment). Positive values before stratification were not considered part of the internal load. Summer internal load amounted to a total of 455 kg, which was more two times the total annual external load of 168 kg (Figure E-1). The last two time steps of the mass balance spreadsheet (9/27 through 10/24/2011) showed net P sedimentation (Figure E-1).

FIGURE E-1: LAKE KETCHUM PHOSPHORUS BUDGET WITH OBSERVED DATA

LAKE KETCHUM P MODEL

Description: Nutrient loads based on a twice monthly timestep water budget and observed data

TP inputs - TP outputs = Net P Sedimentation or Net P Internal Loading

Net P Sedimentation or Net P Internal Loading = (Change in Lake TP Storage + Outflow Output+GW Output) - (Inlet 1 Input + Remaining Inflows Input + Atmospheric TP Deposition)

\* where a (+) results indicates net internal loading of P and a (-) result indicates net sedimentation of P

Assume normal pool volume

363671 m3

Water Year	Bi-Week Number	Date Range		Inflows						Outflows					Lake TP		Residual
		From	To	Direct Precip Load (kg/Period)	Inlet TP Conc. (mg/L)	Inlet Load (kg/Period)	Groundwater Load (kg/Period)	Inlet #2 Load (kg/Period)	Other Inflows Load (kg/Period)	Groundwater TP Conc. (mg/L)	Groundwater Outflow Load (kg/Period)	Outlet V (m³)	Outlet TP Conc. (mg/L)	Outlet Load (kg/Period)	Whole Lake Volume Weighted TP (ug/L)	Change in Lake TP (kg/Period)	Net TP Sedimentation or Net TP Internal Loading
WY 2011	1	10/12/2010	10/25/2010	0.05	0.625	0.13	-0.03	0.00	-0.05	0.279	0.06	150	0.459	0.07	457	-112.41	-112.41
	2	10/26/2010	11/8/2010	0.14	0.652	0.82	0.07	0.01	0.11	0.288	0.02	4,339	0.452	1.96	453	1.66	2.57
	3	11/9/2010	11/22/2010	0.10	0.679	3.52	0.31	0.03	0.52	0.298	0.02	27,352	0.444	12.14	450	-1.40	6.63
	4	11/23/2010	12/6/2010	0.04	0.732	4.12	0.19	0.02	0.31	0.261	0.02	20,726	0.419	8.69	423	-11.17	-6.93
	5	12/7/2010	12/20/2010	0.12	0.777	10.22	0.13	0.01	0.22	0.230	0.02	24,960	0.398	9.93	401	-7.97	-8.58
	6	12/21/2010	1/3/2011	0.02	0.725	4.41	0.16	0.02	0.27	0.221	0.02	17,158	0.375	6.44	374	-10.18	-8.42
	7	1/4/2011	1/17/2011	0.21	0.669	14.84	0.38	0.04	0.64	0.212	0.02	41,505	0.351	14.57	347	-5.94	-7.04
	8	1/18/2011	1/31/2011	0.11	0.653	18.37	0.45	0.04	0.75	0.189	0.02	65,898	0.322	21.21	318	-13.18	-11.19
	9	2/1/2011	2/14/2011	0.05	0.635	8.31	0.22	0.02	0.37	0.161	0.01	29,548	0.288	8.51	285	-13.04	-13.25
	10	2/15/2011	2/28/2011	0.10	0.623	8.41	0.28	0.03	0.46	0.144	0.01	28,746	0.266	7.65	263	-6.75	-8.07
	11	3/1/2011	3/14/2011	0.09	0.601	11.51	0.52	0.05	0.87	0.124	0.01	52,001	0.213	11.08	208	-20.73	-22.11
	12	3/15/2011	3/28/2011	0.09	0.590	10.57	0.60	0.06	0.99	0.115	0.01	54,911	0.188	10.32	182	-9.90	-11.22
	13	3/29/2011	4/11/2011	0.18	0.671	17.41	0.71	0.07	1.17	0.077	0.01	69,835	0.167	11.66	242	23.00	15.91
	14	4/12/2011	4/25/2011	0.05	0.493	5.49	0.51	0.05	0.84	0.021	0.00	40,293	0.127	5.12	249	2.02	0.75
	15	4/26/2011	5/9/2011	0.10	0.791	8.31	0.41	0.04	0.69	0.031	0.00	34,749	0.127	4.41	350	37.57	32.90
	16	5/10/2011	5/23/2011	0.10	1.060	15.51	0.67	0.07	1.12	0.040	0.00	54,141	0.127	6.88	442	33.37	23.53
	17	5/24/2011	6/6/2011	0.03	0.416	2.10	0.61	0.06	1.00	0.066	0.01	34,806	0.135	4.70	671	85.21	86.78
	18	6/7/2011	6/20/2011	0.03	0.458	0.90	0.38	0.04	0.63	0.017	0.00	22,388	0.172	3.85	949	99.99	102.28
	19	6/21/2011	7/4/2011	0.02	0.475	0.35	0.28	0.03	0.47	0.041	0.00	13,446	0.119	1.60	994	14.24	15.01
	20	7/5/2011	7/18/2011	0.03	0.503	0.17	0.24	0.02	0.40	0.002	0.00	9,377	0.078	0.73	774	-81.42	-81.29
	21	7/19/2011	8/1/2011	0.02	0.503	0.06	0.20	0.02	0.33	0.007	0.00	6,580	0.089	0.59	1154	136.10	136.28
	22	8/2/2011	8/15/2011	0.00		0.00	0.12	0.01	0.20	0.008	0.00	2,195	0.072	0.16	1040	-42.93	-42.96
	23	8/16/2011	8/29/2011	0.03		0.00	0.04	0.00	0.06	0.006	0.00	131	0.075	0.01	1061	4.09	4.02
	24	8/30/2011	9/12/2011	0.00		0.00	0.00	0.00	0.00	0.022	0.01	0	0.079	0.00	1174	34.94	34.95
	25	9/13/2011	9/26/2011	0.04		0.00	0.01	0.00	0.01	0.031	0.02	0	0.081	0.00	1234	18.61	18.58
	26	9/27/2011	10/10/2011	0.04		0.00	0.00	0.00	0.00	0.116	0.09	0	0.222	0.00	794	-154.90	-154.85
WY 2008	27	10/11/2011	10/24/2011	0.02		0.00	0.01	0.00	0.02	0.305	0.09	0	0.502	0.00	575	-76.61	-76.56
											0.48			152.27		-77.71	-84.68
Annual Totals				1.79	0.635	145.54	7.48	0.74	12.39		0.48			152.75			
				167.94													

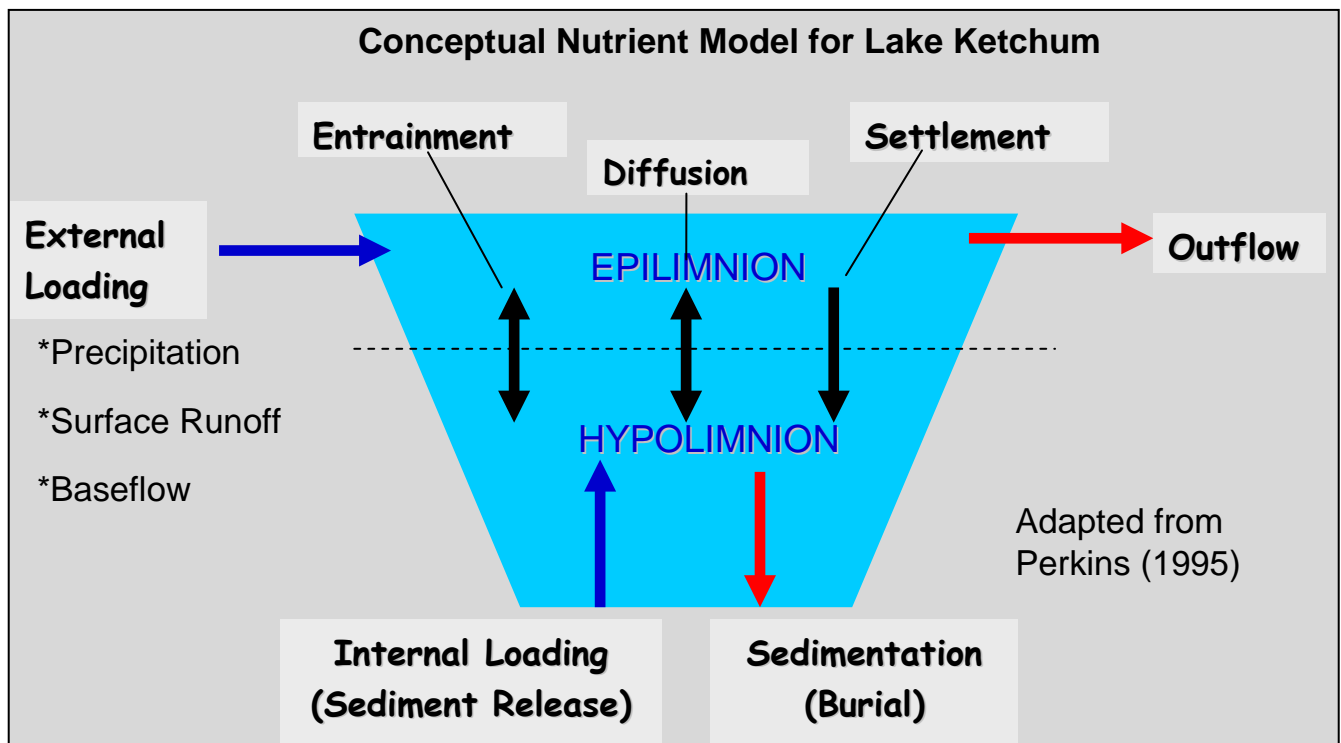
## F LAKE KETCHUM PHOSPHORUS MASS BALANCE MODEL

A two-layer, seasonal mass balance model (Figure F-1) was developed for Lake Ketchum and calibrated against the observed values found in the phosphorus budget. The model is the same type of model used for Lake Onondaga, NY and Lakes Sammamish, Pine and Jameson in WA (Perkins et al., 1997; Auer et al., 1997; Tetra Tech, 2008, 2009). The two-layer model is needed to understand the effect of lake treatment alternatives on the summer phosphorus concentrations in both the epilimnion and hypolimnion. The summer epilimnion concentrations determine the concentration of algae. In addition, the hypolimnetic phosphorus concentrations represent the amount of internal loading occurring that will be affected by lake restoration treatments.

### F.1 MODEL COMPONENTS

The mass balance model uses the same external inputs and outflows as the nutrient budget developed for Lake Ketchum (see Figure F-3 and Figure F-4). However, the internal cycling (entrainment and diffusion), internal loading, and sedimentation required additional calculations and assumptions that are described below (also see Figure F-4, Figure F-5, and Figure F-6).

FIGURE F-1: TWO LAYER PHOSPHORUS MODEL USED FOR LAKE KETCHUM NUTRIENT BUDGET



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### F.1.1 DIFFUSION

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Diffusion is the migration of P from the high P concentrations in the hypolimnion to the lower P concentrations in the epilimnion. The diffusion takes into account the temperature gradient and the chemical gradient found between the stratified layers. It is calculated by the following formula:

$$Diffusion \left( \frac{kg}{wk} \right) = V_t * A_t * (TP_{epi} - TP_{hypo})$$

$V_t$  = vertical exchange coefficient

$A_t$  = area of thermocline

$TP_{epi}$  = concentration of epilimnetic TP

$TP_{hypo}$  = concentration of hypolimnetic TP

The vertical heat exchange coefficient is a measure of the successive differences in heat between the epilimnion and hypolimnion during stratification. It helps to characterize the strength of thermal stratification. The units are in meters per week. It is used to calculate the settling rate during the mixed period as well as to calculate the amount of diffusion of P occurring between the epilimnion and hypolimnion during stratification. The exchange coefficient is based on the following formula:

$$V_T = \frac{(V_h)}{(A_T * t_s)} * \ln \frac{(T_{h,i} - T_e)}{(T_{h,a} - T_e)}$$

$V_h$  = volume of hypolimnion (m<sup>3</sup>)

$T_{h,i}$  = minimum temperature of hypolimnion

$T_{h,a}$  = maximum temperature of hypolimnion

$t_s$  = time between maximum and minimum temp (wk)

$T_e$  = average temperature of epilimnion during stratification

$A_t$  = average surface area of thermocline

For Lake Ketchum, the same exchange coefficient was applied for the entire stratified period and was calculated to be 0.054 meters per week or 0.109 meters for every two weeks. The hypolimnetic and epilimnetic concentrations for the first week are based on measured values from the week before the stratified period. After that the concentrations refer to the modeled value from the previous week (Figure F-4)

This model did not include the role that cyanobacteria may play in bringing additional amounts of phosphorus from the hypolimnion to the epilimnion through their buoyancy controlled activities. This process may also be significant for Lake Ketchum, but was not demonstrated by the current data set.



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### F.1.2 ENTRAINMENT

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Entrainment is the process by which nutrients move from the hypolimnion to the epilimnion when the water column begins to mix either from changing temperatures or wind. As the lake mixes, the thermocline descends and the epilimnion receives a flush of nutrients from the hypolimnion. As entrainment occurs, nutrients become available to algae in the photic zone. Entrainment is estimated by the following formula:

$$\text{Entrainment} \left( \frac{kg}{wk} \right) = (T_{d,f} - T_{d,i}) * A_t (TP_{hypo} - TP_{epi})$$

Where  $T_{d,f}$  = thermocline depth at end of time step

$T_{d,i}$  = thermocline depth at beginning of time step

$A_t$  = area of thermocline

$TP_{hypo}$  = concentration of hypolimnetic TP

$TP_{epi}$  = concentration of epilimnetic TP

Strong and persistent stratification in lakes that are relatively deep per unit area is well known. However, weaker stratification often results in entrainment of hypolimnetic P during summer wind events. The Osgood index (oi), mean z (depth)/va (m/vkm<sup>2</sup>), defines this resistance to mixing and likelihood of P entrainment in summer (Cooke et al., 2005, p. 61). Lakes with an oi of less than 6-7 tend to entrain hypolimnetic P. The oi for Lake Ketchum is 12, indicating that little entrainment is likely. As expected, no direct physical entrainment of hypolimnetic water into the epilimnion was observed during the summer of 2011 based on temperature profiles and observed TP data (Figure F-4). Therefore, the thermocline midpoint was set at 2.5 m in the model. However, in the last time step (10/11/11 – 10/24/11), entrainment was observed and the thermocline depth was dropped to 3 meters. If the study period was extended through the winter period, entrainment would continue to occur as the lake continued to mix.

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### F.1.3 SETTLING/SEDIMENTATION

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Settling or sedimentation is the movement of P through the water column to eventually settle on the lake bottom. It is defined by the settling rate or velocity (m/day). The settling rate is then multiplied by the TP concentration and area of settling. During the mixed period, the settling rate (or burial rate) is constant throughout the water column. When the lake is stratified there are different settling velocities for the epilimnion and the hypolimnion. The hypolimnion settling rate (also the burial rate) is predicted to be lower because the phosphorus is more likely to be in the form of soluble P that was released from the sediments.

In Lake Ketchum, settling rates for the non-stratified period, October – April, were determined by calibrating against observed whole lake TP concentrations (Figure F-6). That rate ranged from 0.03 m/wk at the beginning of the non-stratified period to 0.20 m/wk at the end of the period. Settling from the epilimnion started at 0.5 m/wk and gradually increased to 0.7 m/wk at turnover in September when a higher rate was needed to match observed concentrations (Figure F-6). In the hypolimnion, the total phosphorus and soluble reactive phosphorus (SRP)

were nearly the same throughout the stratified period. Since phosphorus is released (diffused) from sediment pore water as SRP, the settling rate was assumed to be zero at Lake Ketchum. This did not change until turnover when oxidized iron enhanced settling to 0.3 and 0.7 m/wk for the last two periods, respectively (Figure F-6).

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#### F.1.4 INTERNAL LOADING (SEDIMENT RELEASE)

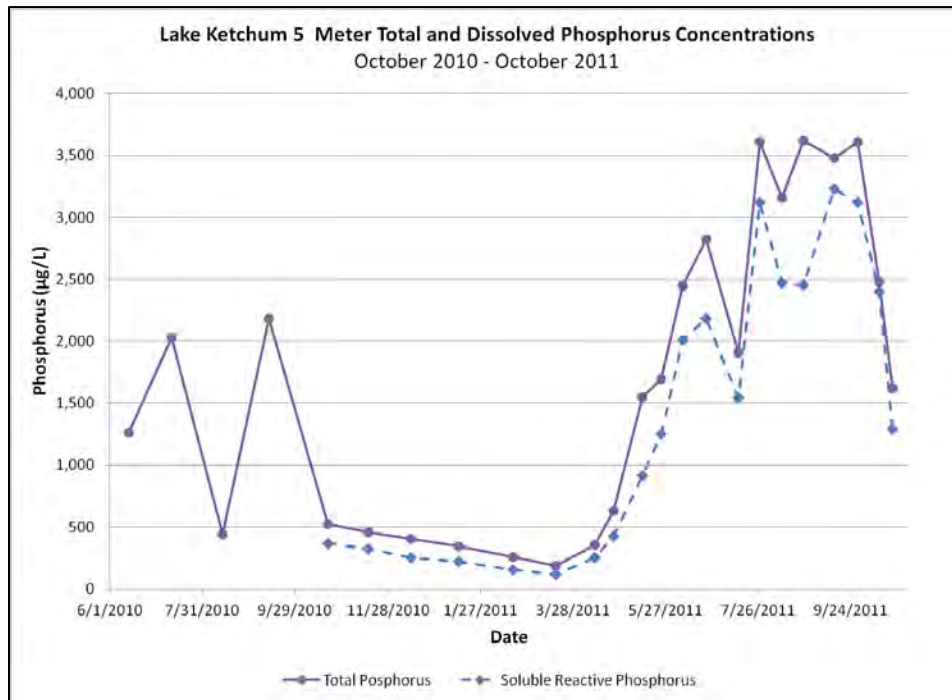
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Internal loading also known as sediment release is the loading of phosphorus from the sediments to the water column. Sediment release typically occurs when oxygen profiles indicate that the lower waters are anoxic (near zero oxygen). The amount of sediment release is based on a sediment release rate (SRR) in kg/week. The release rate is then multiplied by the area of anoxia.

The hypolimnetic gross sediment release in Lake Ketchum was measured by the change in hypolimnetic TP concentrations through the stratified period. The hypolimnetic SRR is considered gross, i.e., no settling loss, as indicated by the nearly equal TP and SRP concentrations (Figure F-2). Phosphorus was being released during 4/12 to 5/9/2011 despite dissolved oxygen concentrations that were above 2 mg/L. Therefore, anoxic depth was set at 6 meters for that period. The anoxic depth for the remaining stratified period was determined from observed dissolved oxygen profiles. The average SRR was estimated by regression analysis at 32 mg/m<sup>2</sup> per day during the anoxic stratified period, with a maximum of 42 mg/m<sup>2</sup> per day. TP content reached over 3 mg/L in the hypolimnion. During calibration, the SRR during the stratified period was increased to 45 mg/m<sup>2</sup> per day to calibrate the model to possibly compensate for P loss to groundwater (Figure F-5).

Some aerobic sediment release was also assumed to occur, because shallow unstratified aerobic lakes have summer internal loading, e.g., 6 mg/m<sup>2</sup> per day in Upper Klamath, OR and 2.6 mg/m<sup>2</sup> per day in Long Lake (Kitsap) WA (Welch and Cooke, 1995). Aerobic release is especially likely if the Total Iron (TFe) to TP ratio in surficial sediment is less than fifteen to one 15:1 (Jenset et al., 1992). This is the case in Lake Ketchum as explained in Section E.3. Therefore, a rate of 2 mg/m<sup>2</sup> per day was assumed for Lake Ketchum epilimnetic sediment aerobic release during the stratified period.

FIGURE F-2: COMPARISON OF HYPOLIMNETIC TOTAL AND DISSOLVED (SOLUBLE REACTIVE) PHOSPHORUS CONCENTRATIONS



## F.2 MODEL CALIBRATION

Several iterations and adjustments were required to calibrate the mass balance model to closely approximate the observed lake conditions. First during the non-stratified period, known ranges of settling were used to calibrate the model by comparing against observed whole lake TP concentrations. Additional adjustments were made to account for aerobic sediment release seen in the phosphorus budget. During the stratified period, the sediment release rate, derived from the build-up of phosphorus concentrations in the hypolimnion, was used in the model. The model was then calibrated by making adjustments to the settling rate. The final calibrated model closely aligned with the observed values. (See Figure F-7, Figure F-8, and Figure F-9.)

FIGURE F-3: LAKE KETCHUM PHOSPHORUS MODEL PART 1 - INFLOWS

**2011WY Phosphorus Prediction Model**

Bi-Week Number	Date Range		INFLOW									
	From	To	Precipitation Load (kg/period)	Inlet TP Conc. (mg/L)	Inlet Load (kg/Period)	Groundwater TP (mg/L)	Groundwater Load (kg/Period)	Inlet #2 TP (mg/L)	Inlet #2 Load (kg/Period)	Other Inflows TP (mg/L)	Other Inflows Load (kg/Period)	Inflow Total (kg)
1	10/12/2010	10/25/2010	0.049	0.625	0.13	0.03	-0.03	0.10	0.00	0.07	-0.05	0.09
2	10/26/2010	11/8/2010	0.136	0.652	0.82	0.03	0.07	0.10	0.01	0.07	0.11	1.14
3	11/9/2010	11/22/2010	0.098	0.679	3.52	0.03	0.31	0.10	0.03	0.07	0.52	4.48
4	11/23/2010	12/6/2010	0.038	0.732	4.12	0.03	0.19	0.10	0.02	0.07	0.31	4.67
5	12/7/2010	12/20/2010	0.120	0.777	10.22	0.03	0.13	0.10	0.01	0.07	0.22	10.70
6	12/21/2010	1/3/2011	0.018	0.725	4.41	0.03	0.16	0.10	0.02	0.07	0.27	4.87
7	1/4/2011	1/17/2011	0.207	0.669	14.84	0.03	0.38	0.10	0.04	0.07	0.64	16.11
8	1/18/2011	1/31/2011	0.110	0.653	18.37	0.03	0.45	0.10	0.04	0.07	0.75	19.72
9	2/1/2011	2/14/2011	0.050	0.635	8.31	0.03	0.22	0.10	0.02	0.07	0.37	8.98
10	2/15/2011	2/28/2011	0.102	0.623	8.41	0.03	0.28	0.10	0.03	0.07	0.46	9.28
11	3/1/2011	3/14/2011	0.094	0.601	11.51	0.03	0.52	0.10	0.05	0.07	0.87	13.05
12	3/15/2011	3/28/2011	0.086	0.590	10.57	0.03	0.60	0.10	0.06	0.07	0.99	12.31
13	3/29/2011	4/11/2011	0.180	0.671	17.41	0.03	0.71	0.10	0.07	0.07	1.17	19.54
14	4/12/2011	4/25/2011	0.054	0.493	5.49	0.03	0.51	0.10	0.05	0.07	0.84	6.95
15	4/26/2011	5/9/2011	0.096	0.791	8.31	0.03	0.41	0.10	0.04	0.07	0.69	9.55
16	5/10/2011	5/23/2011	0.101	1.060	15.51	0.03	0.67	0.10	0.07	0.07	1.12	17.47
17	5/24/2011	6/6/2011	0.032	0.416	2.10	0.03	0.61	0.10	0.06	0.07	1.00	3.80
18	6/7/2011	6/20/2011	0.032	0.458	0.90	0.03	0.38	0.10	0.04	0.07	0.63	1.98
19	6/21/2011	7/4/2011	0.017	0.475	0.35	0.03	0.28	0.10	0.03	0.07	0.47	1.14
20	7/5/2011	7/18/2011	0.032	0.503	0.17	0.03	0.24	0.10	0.02	0.07	0.40	0.86
21	7/19/2011	8/1/2011	0.015	0.503	0.06	0.03	0.20	0.10	0.02	0.07	0.33	0.62
22	8/2/2011	8/15/2011	0.000		0.00	0.03	0.12	0.10	0.01	0.07	0.20	0.33
23	8/16/2011	8/29/2011	0.028		0.00	0.03	0.04	0.10	0.00	0.07	0.06	0.13
24	8/30/2011	9/12/2011	0.000		0.00	0.03	0.00	0.10	0.00	0.07	0.00	0.00
25	9/13/2011	9/26/2011	0.036		0.00	0.03	0.01	0.10	0.00	0.07	0.01	0.06
26	9/27/2011	10/10/2011	0.040		0.00	0.03	0.00	0.10	0.00	0.07	0.00	0.04
27	10/11/2011	10/24/2011	0.019		0.00	0.03	0.01	0.10	0.00	0.07	0.02	0.06
Annual Totals			1.8		145.5		7.5		0.7		12.4	167.9
Phosphorus Concentration Assumptions			0.02 mg/L				0.03 mg/L		0.17 mg/L		0.07 mg/L	

FIGURE F-4: LAKE KETCHUM PHOSPHORUS MODEL PART 2 - OUTFLOWS &amp; INTERNAL FLUX (ENTRAINMENT/DIFFUSION)

**2011WY Phosphorus Prediction Model**

Bi-Week Number	Date Range		OUTFLOW						INTERNAL CYCLING	
	From	To	Outlet TP Conc. (mg/L)	Outlet Load (kg/Period)	Groundwater Outflow (m3)	Groundwater TP Conc. (mg/L)	Groundwater Outflow Load (kg/Period)	Outflow Total (kg)	Entrainment (kg/Period)	Diffusion (kg/Period)
1	10/12/2010	10/25/2010	0.459	0.07	200	0.279	0.056	0.12	0.0	0.0
2	10/26/2010	11/8/2010	0.457	1.98	80	0.291	0.023	2.00	0.0	0.0
3	11/9/2010	11/22/2010	0.439	12.00	80	0.294	0.024	12.02	0.0	0.0
4	11/23/2010	12/6/2010	0.411	8.52	80	0.256	0.021	8.54	0.0	0.0
5	12/7/2010	12/20/2010	0.398	9.92	80	0.229	0.018	9.94	0.0	0.0
6	12/21/2010	1/3/2011	0.392	6.72	80	0.231	0.018	6.74	0.0	0.0
7	1/4/2011	1/17/2011	0.377	15.66	80	0.228	0.018	15.68	0.0	0.0
8	1/18/2011	1/31/2011	0.335	22.08	80	0.196	0.016	22.09	0.0	0.0
9	2/1/2011	2/14/2011	0.307	9.08	80	0.172	0.014	9.09	0.0	0.0
10	2/15/2011	2/28/2011	0.283	8.13	80	0.153	0.012	8.15	0.0	0.0
11	3/1/2011	3/14/2011	0.251	13.06	80	0.146	0.012	13.07	0.0	0.0
12	3/15/2011	3/28/2011	0.223	12.26	80	0.136	0.011	12.27	0.0	0.0
13	3/29/2011	4/11/2011	0.199	13.88	80	0.091	0.007	13.89	0.0	0.0
14	4/12/2011	4/25/2011	0.191	7.69	80	0.032	0.003	7.69	0.0	0.0
15	4/26/2011	5/9/2011	0.126	4.38	80	0.031	0.002	4.38	0.0	-1.9
16	5/10/2011	5/23/2011	0.131	7.12	80	0.041	0.003	7.12	0.0	-2.6
17	5/24/2011	6/6/2011	0.157	5.48	80	0.077	0.006	5.49	0.0	-4.2
18	6/7/2011	6/20/2011	0.128	2.86	100	0.012	0.001	2.86	0.0	-6.7
19	6/21/2011	7/4/2011	0.123	1.66	100	0.042	0.004	1.66	0.0	-8.8
20	7/5/2011	7/18/2011	0.128	1.20	100	0.003	0.000	1.20	0.0	-11.1
21	7/19/2011	8/1/2011	0.135	0.89	250	0.010	0.002	0.89	0.0	-13.5
22	8/2/2011	8/15/2011	0.150	0.33	500	0.017	0.008	0.34	0.0	-15.7
23	8/16/2011	8/29/2011	0.172	0.02	500	0.014	0.007	0.03	0.0	-17.9
24	8/30/2011	9/12/2011	0.198	0.00	500	0.055	0.028	0.03	0.0	-19.7
25	9/13/2011	9/26/2011	0.225	0.00	500	0.085	0.042	0.04	0.0	-21.4
26	9/27/2011	10/10/2011	0.249	0.00	800	0.130	0.104	0.10	0.0	-23.1
27	10/11/2011	10/24/2011	0.257	0.00	300	0.156	0.047	0.05	71.9	-15.6
Annual Totals				165.0			0.5	165.5	71.9	-162.0

FIGURE F-5: LAKE KETCHUM PHOSPHORUS MODEL PART 3 – AENEROBIC AND AEROBIC INTERNAL LOADING (SEDIMENT RELEASE)

			Anaerobic Release		Period	Aerobic Release		Period
			SRR (mg-m <sup>2</sup> /day)	45.0	5/10/2010-10/24/2011	SRR (mg-m <sup>2</sup> /day)	2.0	
2011WY Phosphorus Prediction Model								
Bi-Week Number	Date Range		INTERNAL LOADING (Anaerobic)			INTERNAL LOADING (Aerobic)		
	From	To	SRR (mg-m <sup>2</sup> /day)	Anoxic Area (m <sup>2</sup> )	Internal Loading (kg/Period)	SRR (mg-m <sup>2</sup> /day)	Aerobic Area (m <sup>2</sup> )	Internal Loading (kg/Period)
1	10/12/2010	10/25/2010	45.00	0	0.00	0.00	102869	0.00
2	10/26/2010	11/8/2010	45.00	0	0.00	0.00	103701	0.00
3	11/9/2010	11/22/2010	45.00	0	0.00	0.00	103657	0.00
4	11/23/2010	12/6/2010	45.00	0	0.00	0.00	103219	0.00
5	12/7/2010	12/20/2010	45.00	0	0.00	0.00	103351	0.00
6	12/21/2010	1/3/2011	45.00	0	0.00	0.00	103132	0.00
7	1/4/2011	1/17/2011	45.00	0	0.00	0.00	104708	0.00
8	1/18/2011	1/31/2011	45.00	0	0.00	0.00	103745	0.00
9	2/1/2011	2/14/2011	45.00	0	0.00	0.00	103438	0.00
10	2/15/2011	2/28/2011	45.00	0	0.00	0.00	104008	0.00
11	3/1/2011	3/14/2011	45.00	0	0.00	0.00	103964	0.00
12	3/15/2011	3/28/2011	45.00	0	0.00	0.00	103876	0.00
13	3/29/2011	4/11/2011	45.00	0	0.00	0.00	104095	0.00
14	4/12/2011	4/25/2011	45.00	13814	8.70	2.00	90106	2.52
15	4/26/2011	5/9/2011	45.00	13814	8.70	2.00	90018	2.52
16	5/10/2011	5/23/2011	45.00	47861	30.15	2.00	55797	1.56
17	5/24/2011	6/6/2011	45.00	60371	38.03	2.00	43374	1.21
18	6/7/2011	6/20/2011	45.00	60371	38.03	2.00	42980	1.20
19	6/21/2011	7/4/2011	45.00	73801	46.49	2.00	29243	0.82
20	7/5/2011	7/18/2011	45.00	77029	48.53	2.00	25840	0.72
21	7/19/2011	8/1/2011	45.00	77322	48.71	2.00	25284	0.71
22	8/2/2011	8/15/2011	45.00	77761	48.99	2.00	24625	0.69
23	8/16/2011	8/29/2011	45.00	69388	43.71	2.00	32604	0.91
24	8/30/2011	9/12/2011	45.00	65700	41.39	2.00	35678	1.00
25	9/13/2011	9/26/2011	45.00	63778	40.18	2.00	37293	1.04
26	9/27/2011	10/10/2011	45.00	47711	30.06	2.00	53228	1.49
27	10/11/2011	10/24/2011	45.00	40663	25.62	2.00	60232	1.69
		Annual Totals			497.3			18.1

FIGURE F-6: LAKE KETCHUM PHOSPHORUS MODEL PART 4 – SEDIMENTATION

**2011WY Phosphorus Prediction Model**

Bi-Week Number	Date Range		SEDIMENTATION					
	From	To	Settling Rate Epi (m/week) (VT = 0.109)	Settling Rate Hypo (m/week)	Anoxic Area (A <sub>T</sub> ) (m <sup>2</sup> )	Sedimentation (kg/Period)	Hypo Sedimentation (kg/Period)	Epi Sedimentation (kg/Period)
1	10/12/2010	10/25/2010	0.03		102,869	2.82	0.00	0.00
2	10/26/2010	11/8/2010	0.03		103,701	2.84	0.00	0.00
3	11/9/2010	11/22/2010	0.03		103,657	2.73	0.00	0.00
4	11/23/2010	12/6/2010	0.03		103,219	2.55	0.00	0.00
5	12/7/2010	12/20/2010	0.03		103,351	2.46	0.00	0.00
6	12/21/2010	1/3/2011	0.05		103,132	4.04	0.00	0.00
7	1/4/2011	1/17/2011	0.15		104,708	11.86	0.00	0.00
8	1/18/2011	1/31/2011	0.15		103,745	10.43	0.00	0.00
9	2/1/2011	2/14/2011	0.15		103,438	9.53	0.00	0.00
10	2/15/2011	2/28/2011	0.20		104,008	11.77	0.00	0.00
11	3/1/2011	3/14/2011	0.20		103,964	10.44	0.00	0.00
12	3/15/2011	3/28/2011	0.20		103,876	9.27	0.00	0.00
13	3/29/2011	4/11/2011	0.20		104,095	8.28	0.00	0.00
14	4/12/2011	4/25/2011	0.50	0.00	66,438	0.00	0.00	8.37
15	4/26/2011	5/9/2011	0.50	0.00	66,438	0.00	0.00	8.37
16	5/10/2011	5/23/2011	0.50	0.00	66,438	0.00	0.00	8.73
17	5/24/2011	6/6/2011	0.50	0.00	66,438	0.00	0.00	10.46
18	6/7/2011	6/20/2011	0.50	0.00	66,438	0.00	0.00	8.49
19	6/21/2011	7/4/2011	0.50	0.00	66,438	0.00	0.00	8.18
20	7/5/2011	7/18/2011	0.60	0.00	66,438	0.00	0.00	10.24
21	7/19/2011	8/1/2011	0.60	0.00	66,438	0.00	0.00	10.74
22	8/2/2011	8/15/2011	0.60	0.00	66,438	0.00	0.00	11.98
23	8/16/2011	8/29/2011	0.60	0.00	66,438	0.00	0.00	13.68
24	8/30/2011	9/12/2011	0.60	0.00	66,438	0.00	0.00	15.79
25	9/13/2011	9/26/2011	0.60	0.00	66,438	0.00	0.00	17.97
26	9/27/2011	10/10/2011	0.70	0.30	66,438	0.00	137.56	23.19
27	10/11/2011	10/24/2011	0.70	0.70	59,036	0.00	222.49	21.24
Annual Totals						89.0	360.1	177.4

FIGURE F-7: LAKE KETCHUM PHOSPHORUS MODEL PART 5 – MODEL PREDICTED VERSUS OBSERVED LAKE CONCENTRATIONS

**2011 WY Phosphorus Prediction Model**

Bi-Week Number	Date Range		PREDICTIONS (ug/l)				OBSERVED DATA (ug/l)		
	From	To	Predicted Whole Lake Concentrations (ug/L)	Predicted Eplimnetic Lake Conc. (ug/L)	Predicted Hypolimnetic Lake Conc. (ug/L)	Volume-Weighted Whole Lake TP Concentration (ug/l)	Observed Whole Lake Concentration (ug/L)	Hypolimnetic TP Concentration (ug/L)	Epilimnetic TP Concentration (ug/L)
1	10/12/2010	10/25/2010	457				457		
2	10/26/2010	11/8/2010	439				453		
3	11/9/2010	11/22/2010	411				450		
4	11/23/2010	12/6/2010	398				423		
5	12/7/2010	12/20/2010	392				401		
6	12/21/2010	1/3/2011	377				374		
7	1/4/2011	1/17/2011	335				347		
8	1/18/2011	1/31/2011	307				318		
9	2/1/2011	2/14/2011	283				285		
10	2/15/2011	2/28/2011	251				263		
11	3/1/2011	3/14/2011	223				208		
12	3/15/2011	3/28/2011	199				182		
13	3/29/2011	4/11/2011	191				242		
14	4/12/2011	4/25/2011	-	126	383	224	224	383	126
15	4/26/2011	5/9/2011	-	131	490	268	339	680	127
16	5/10/2011	5/23/2011	-	157	747	383	442	947	129
17	5/24/2011	6/6/2011	-	128	1,059	484	565	1,235	151
18	6/7/2011	6/20/2011	-	123	1,341	592	785	1,805	147
19	6/21/2011	7/4/2011	-	128	1,665	724	820	1,896	138
20	7/5/2011	7/18/2011	-	135	2,002	861	633	1,498	82
21	7/19/2011	8/1/2011	-	150	2,327	1,002	1,030	2,465	108
22	8/2/2011	8/15/2011	-	172	2,647	1,145	1,040	2,493	100
23	8/16/2011	8/29/2011	-	198	2,926	1,279	1,313	3,005	202
24	8/30/2011	9/12/2011	-	225	3,191	1,416	1,449	3,259	235
25	9/13/2011	9/26/2011	-	249	3,451	1,543	1,523	3,395	253
26	9/27/2011	10/10/2011	-	257	2,692	1,244	1,212	2,655	229
27	10/11/2011	10/24/2011	-	507	1,077	685	763	1,324	507



FIGURE F-8: LAKE KETCHUM MODEL PERFORMANCE FOR MIXED AND STRATIFIED PERIODS

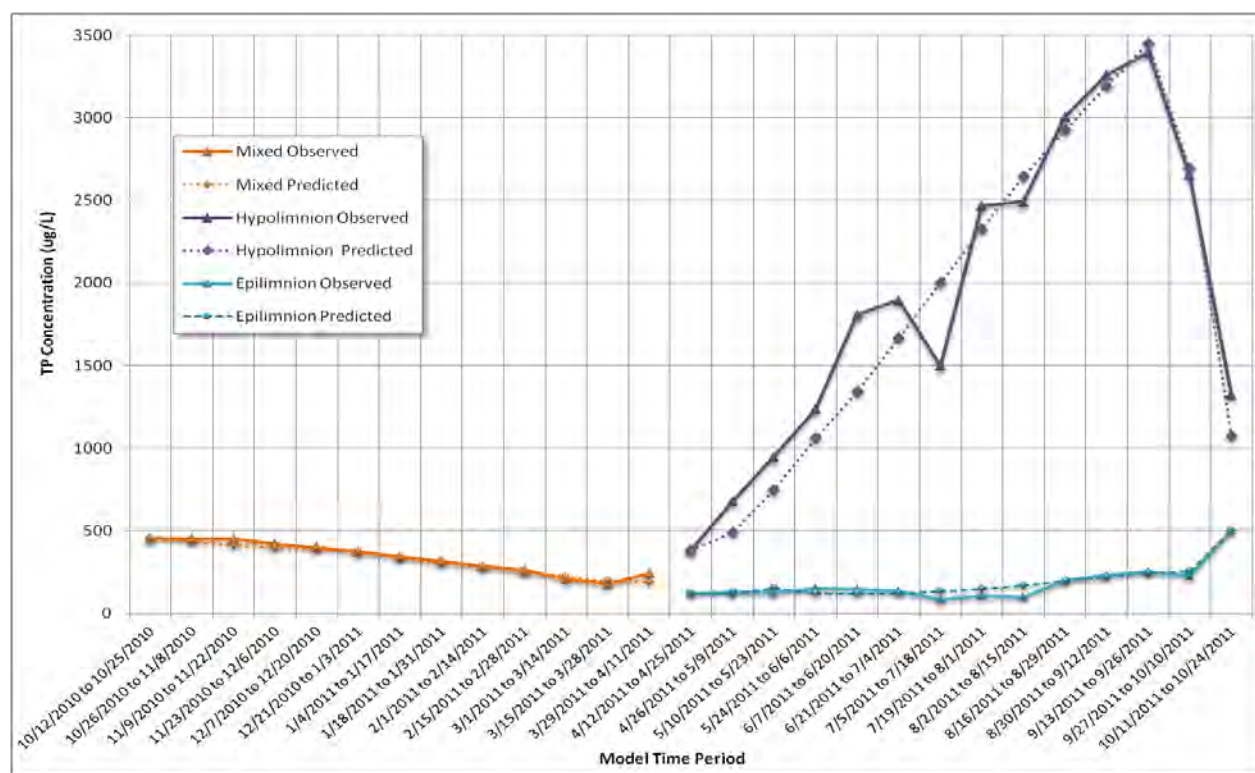
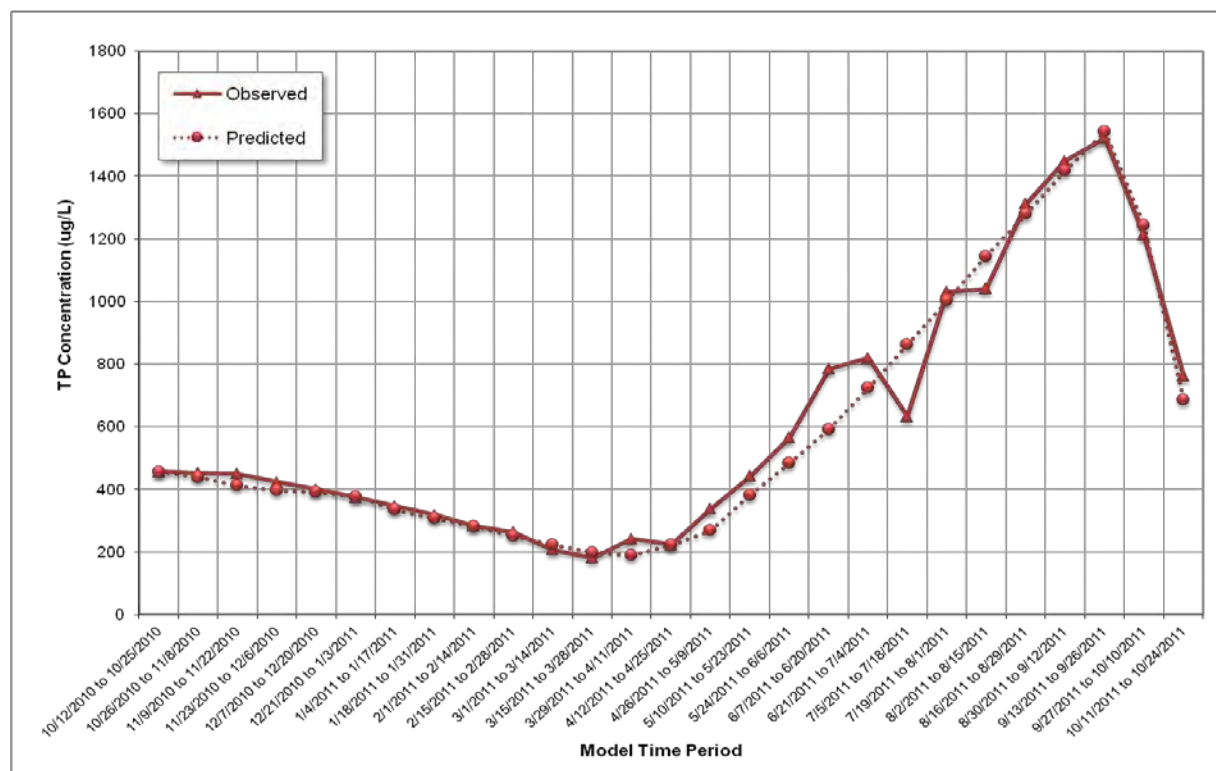


FIGURE F-9: LAKE KETCHUM MODEL PERFORMANCE –WHOLE LAKE VOLUME WEIGHTED



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### F.3 MODEL RESULTS FOR PROPOSED RESTORATION ALTERNATIVES

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As described in the control plan, Tetra Tech evaluated four lake restoration alternatives, each of which involved the application of aluminum sulfate (alum) to the lake to permanently bind the phosphorus. The model was adapted to determine the lake's response with respect to phosphorus concentrations in each of the following restoration alternatives:

1. Whole-lake sediment inactivation alum treatment
2. Whole-lake sediment inactivation alum treatment repeated in two years.
3. Whole-lake sediment inactivation alum treatment with alum injection at inlet.
4. Whole-lake sediment inactivation alum treatment with annual water column alum treatments.

The primary assumption in this analysis is that environmental conditions in the treatment years would be similar to the study year. Although this is a reasonable assumption, year-to-year climate variations will affect stratification and external loading. Seasonal conditions may also influence the role cyanobacteria may play in vertical transport of phosphorus through sinking/buoyancy regulation that is not currently accounted for in the model.

A whole-lake sediment inactivation treatment was assumed to reduce internal loading of total phosphorus from both anoxic and oxic sediments, as well as from the water column, by about 85%. The 85% effectiveness is an estimate based on reductions in the sediment release rate (SRR) seen in four stratified lakes with adequate data (Mirror, Shadow, W. Twin and Morey). In this study, the sediment release rate declined 90% in response to relatively low alum doses averaging 12.5 mg/L Al (Cooke et al., 2005).

The algae control plan highlighted the lake responses in the epilimnion to each restoration alternative. Figure F-10 through Figure F-12 illustrate the effect of the various restoration alternatives on the hypolimnion total phosphorus concentrations. Similar to the effect seen on the epilimnion, all alternatives initially reduce hypolimnetic phosphorus. Even in these scenarios, there is still a significant amount of sediment release that occurs each stratified period. Since the alum treatments are only considered 85% effective, the sediment release rate is still high following treatments in all alternatives. Alternatives 3 and 4 achieve the most effective long-term control of hypolimnetic phosphorus (Figure F-9, Figure F-11 and Figure F-12).

FIGURE F-10 : HYPOLIMNETIC CONCENTRATIONS IN RESPONSE TO RESTORATION ALTERNATIVES 1 &amp; 2

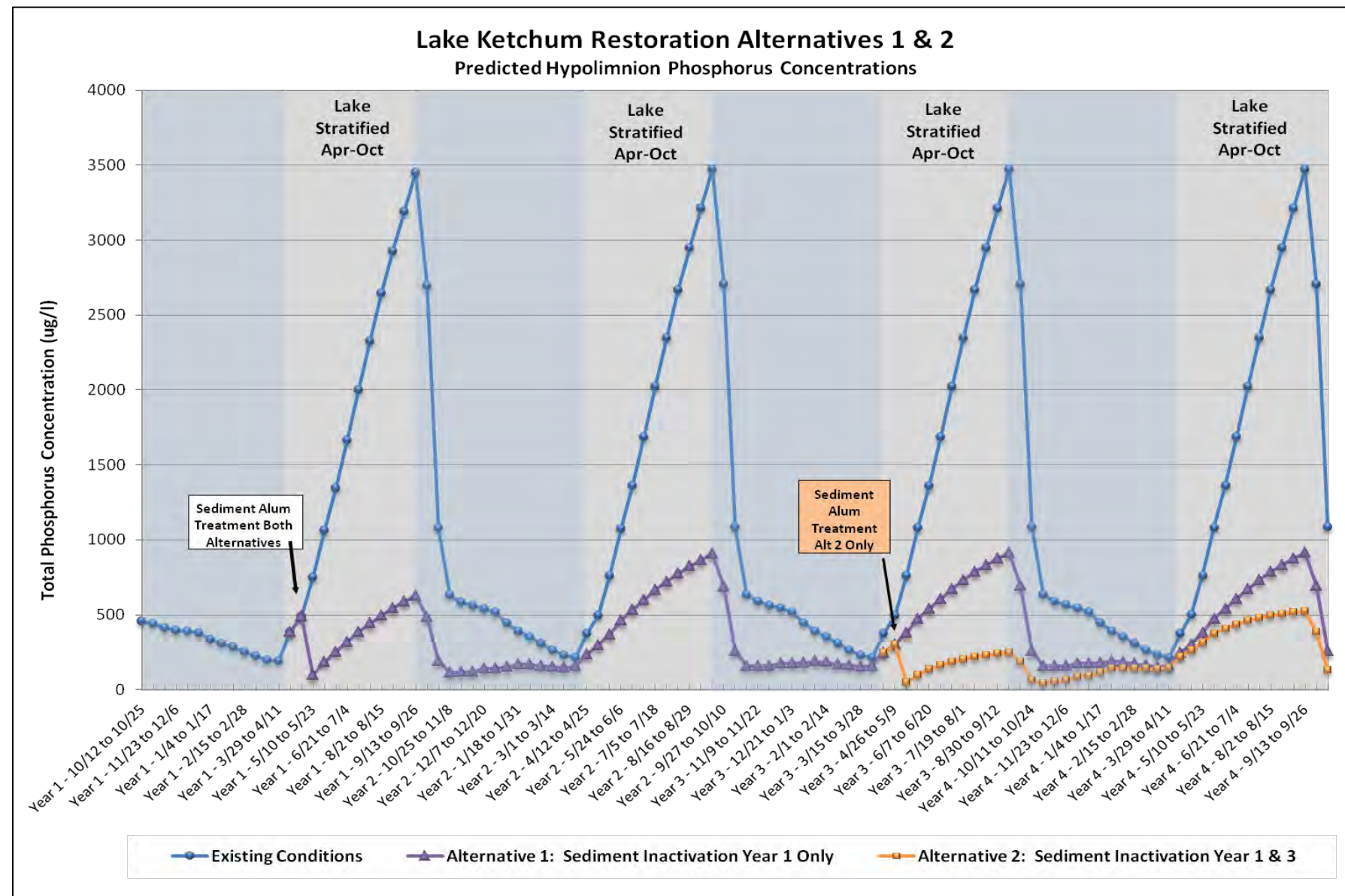




FIGURE F-11 : HYPOLIMNETIC PHOSPHORUS CONCENTRATIONS IN RESPONSE TO RESTORATION ALTERNATIVES 3 &amp; 4

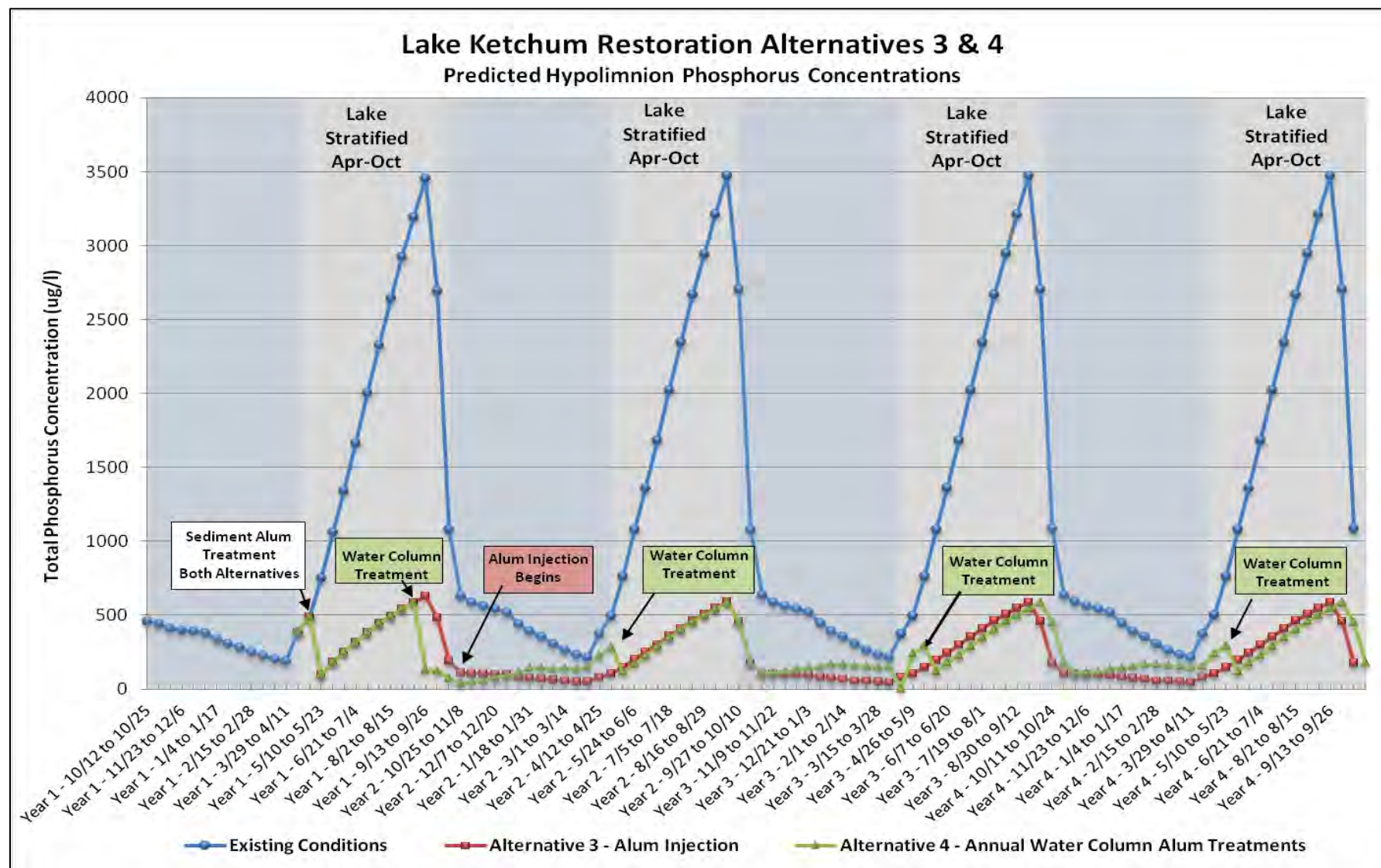
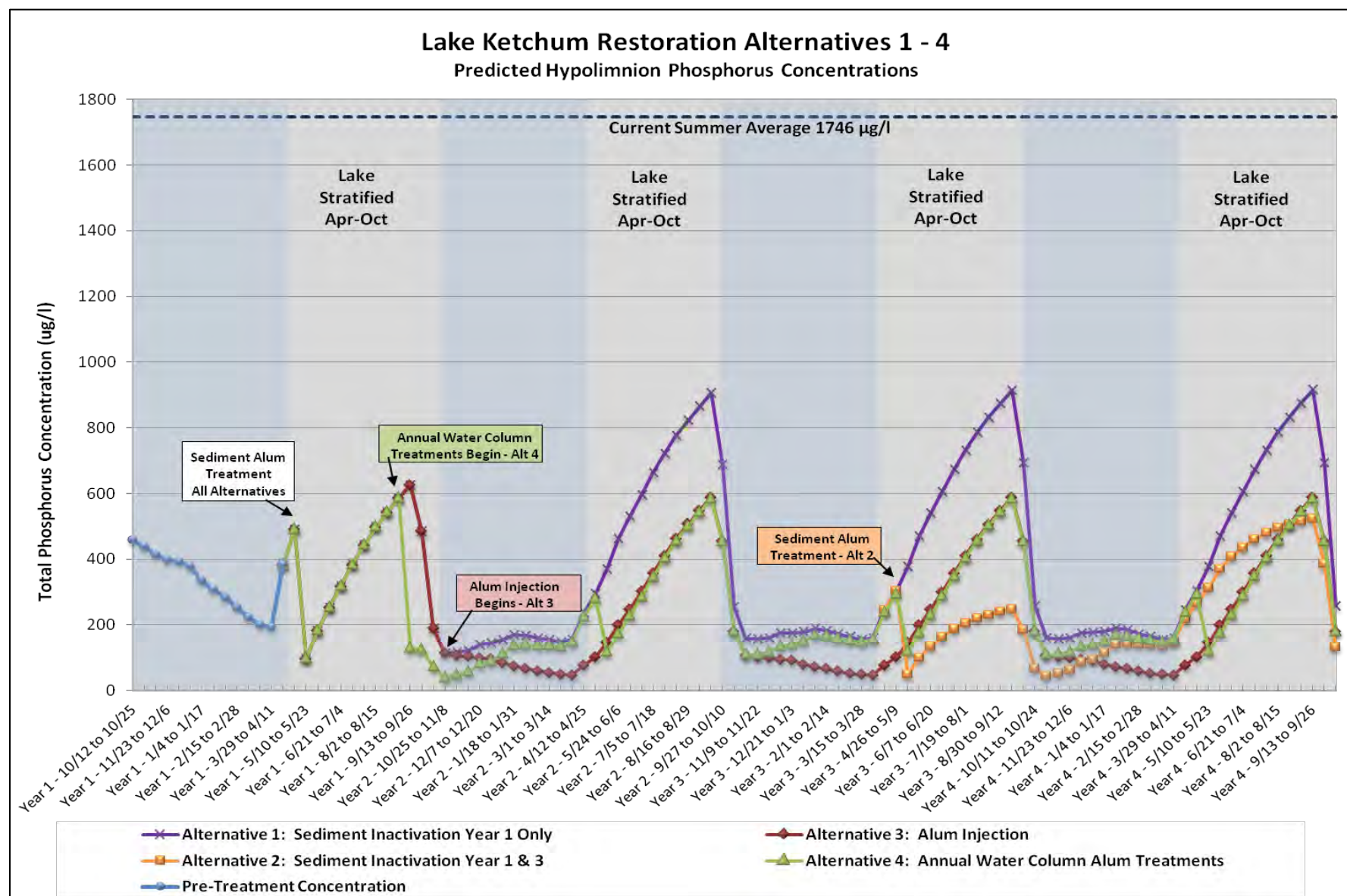


FIGURE F-12 : HYPOLIMNETIC PHOSPHORUS CONCENTRATIONS IN RESPONSE TO ALL RESTORATION ALTERNATIVES



## G ALUM DOSE RATES AND COST ESTIMATES

### G.1 ALUMINUM DOSE REQUIREMENTS

The amount of aluminum needed for a lake-wide sediment treatment was calculated based upon the sediment results described above in Section C. The following equation with adjustments for appropriate units was used to determine the appropriate aluminum dose to inactivate phosphorus in the deep sediments of the lake:

$$Al = P_{avail} * BD * D_{sed} * Al:P/z$$

Where:

- $Al$  = Aluminum dose (kg/L)
- $P_{avail}$  = Available phosphorus in sediment (mg/g)
- $BD$  = Bulk density of solids in sediment (g/cm<sup>3</sup>)
- $D_{sed}$  = Depth of active sediment zone (cm)
- $Al:P$  = The ratio of Al added to available phosphorus
- $z$  = average depth of the lake (m)

The aluminum dose rate was first calculated for deep areas of the lake or the area greater than 15 feet depth (4.57 m). The target zone for the sediment treatment in Lake Ketchum is the first 10 cm of sediment, as this is the most active zone of biochemical mineralization. In addition, the total phosphorus in the deep sediment profile is significantly lower after the first 10 cm (Figure C-2). The available-P (loosely sorbed-P + Fe-P + biogenic-P) at the deep site averaged 0.805 mg/g in the top 10 cm (Figure C-2). The sediment bulk density (BD) was found to be 1.052 g/cm<sup>3</sup>, the solids portion of this bulk density is 0.052 g/cm<sup>3</sup> and was used in the formula above. A ratio of 20:1 for Al added to available-P was determined to be needed to inactivate sediment phosphorus. The 20:1 ratio for 10 cm was derived from the 100:1 ratio for 4 cm proposed by Rydin and Welch (1999). However, non-reactive (nr)-P, or biogenic-P, was not included in those calculations, but was about equal to mobile (Fe-P + loosely sorbed P) in those Wisconsin lake sediments. Therefore, had biogenic-P been included, the ratio would have been lowered to 50:1, and extending the depth to 10 cm from 4 cm would further lower it to 20:1. These factors were multiplied together as shown in the above equation to find the areal aluminum dose rate of 83.72 grams of Al/m<sup>2</sup>. The areal aluminum dose (in g/m<sup>2</sup>) was divided by the mean lake depth of 3.5 meters to obtain a volumetric dose of 24 mg Al/L.

The same procedures were followed to calculate a dose rate in areas less than 15 feet deep. With a lower available P of 0.571 mg/g in these areas, the dose for shallower areas was determined to be 60 g/m<sup>2</sup> Al/L. However, given that the deeper sediments yielded a higher dose requirement than the shallower sediments, it is recommended that the higher dose rate of 24 mg Al/L be used to determine the volumetric dose in Al concentration and to provide a measure of safety.

The water column contained about 200 µg/L TP prior to stratification. This concentration multiplied by the 20:1 ratio gives an additional water column stripping dose of 4 mg Al/L. Therefore, the total volumetric dose (sediment inactivation + water column stripping) is 28 mg Al/L.

## G.2 ALUM AND BUFFER REQUIREMENTS

With the high dose of aluminum needed for Lake Ketchum, both aluminum sulfate and the buffer sodium aluminate will be needed. The following assumptions were used to determine the specific amounts of each compound for the initial sediment treatment as well as for the annual water column treatments.

### Dosage Assumptions:

- Initial Aluminum Treatment Dose (sediment & water column): 28 mg/L
- Water Column Treatment Dose: 4 mg/L
- Lake volume, 363,670 m<sup>3</sup>
- Ratio of Al from Alum:Sodium Aluminate by weight is = 44:56
- Volume application rate 2:1 Alum:Sodium Aluminate
- Al per gallon Alum = 0.22 kg
- Al per gallon Sodium Aluminate = 0.56 kg

FIGURE G-1: AMOUNT OF ALUM & SODIUM ALUMINATE REQUIRED FOR INITIAL TREATMENT & ANNUAL WATER COLUMN TREATMENTS

Sediment Treatment				Water Column Treatment			
	Alum	Sodium Aluminate	Total		Alum	Sodium Aluminate	Total
Amount of Aluminum (kg)	4,484	5,708	<b>10,192</b>	Amount of Aluminum (kg)	641	815	<b>1,456</b>
Volume (gal)	20,384	10,192		Volume (gal)	2,912	1,456	

## G.3 ALUM TREATMENT COST ESTIMATES

The projected costs of the whole-lake sediment inactivation alum treatment and the annual water column treatments were derived from experiences with recent alum treatments in Washington state and Ohio. Figure G-2 provides the assumptions and cost calculations for the sediment treatment. Figure G-3 provides the assumptions and calculations for the annual water column alum treatments. All costs are in 2011 dollars.

FIGURE G-2: COST ESTIMATE FOR SEDIMENT PHOSPHORUS INACTIVATION ALUM TREATMENT

Assumptions			
Applied cost of alum per gallon -- \$2.50			
Applied cost of sodium aluminate per gallon -- \$3.80			
Mobilization -- 20% of total applied costs			
Tax -- 9% of total applied costs and mobilization			
Planning/Design/Permitting (P/D/P) -- 35% of applied costs plus mobilization and taxes			
Contingency -- 30% of applied costs plus mobilization and taxes			
Item	Unit Cost	# of Units	Item cost
Alum	\$2.50 per gallon	20400 gallons	\$ 51,000
Sodium Aluminate	\$3.80 per gallon	10200 gallons	\$ 38,760
		Subtotal	\$ 89,760
Mobilization	20% of subtotal		\$ 17,952
		New Subtotal	\$ 107,712
Tax	9% of new subtotal		\$ 9,694
		Final Subtotal	\$ 117,406
P/D/P	35% of final subtotal		\$ 41,092
Contingency	30% of final subtotal		\$ 35,222
		<b>Total Cost</b>	<b>\$ 193,720</b>



FIGURE G-3: COST ESTIMATE FOR WATER COLUMN ALUM TREATMENTS

<u>Assumptions</u>			
Applied cost of alum per gallon -- \$3.50			
Applied cost of sodium aluminate per gallon -- \$4.80			
Mobilization -- 20% of total applied costs			
Note: costs of alum and sodium aluminate materials and application and			
costs for mobilization are higher than for sediment treatment because of			
much smaller quantities			
Tax -- 9% of total applied costs and mobilization			
Planning/Design/Permitting (P/D/P) -- 18% of applied costs plus mobilization and taxes			
Contingency -- 30% of applied costs plus mobilization and taxes			
Item	Unit Cost	# of Units	Item cost
Alum	\$3.50 per gallon	2912 gallons	\$ 10,192
Sodium Aluminate	\$4.80 per gallon	1456 gallons	\$ 6,989
		Subtotal	\$ 17,181
Mobilization	30% of subtotal		\$ 5,154
		New Subtotal	\$ 22,335
Tax	9% of new subtotal		\$ 2,010
		Final Subtotal	\$ 24,345
P/D/P	18% of final subtotal		\$ 4,382
Contingency	30% of final subtotal		\$ 7,304
		<b>Total Cost</b>	<b>\$ 36,031</b>

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